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Report on

Vision of Aerospace Command and Control For the 21st Century

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Vision of Aerospace Command and Control For the 21st Century

Executive Summary

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This summary is a product of the United States Air Force Scientific Advisory Board Study on *Vision of Aerospace Command and Control For the 21st Century*. Statements, opinions, recommendations and conclusions contained in this report are those of the study members and do not necessarily represent the official position of the USAF or the Department of Defense.

Executive Summary

Introduction

The Air Force Scientific Advisory Board (SAB) was chartered to help develop a Vision for Aerospace Command and Control (C2) for the 21st Century. This task was accomplished in a collaborative effort with Air Force representatives from the Air Staff, Air Combat Command, Air Mobility Command, and Air Force Space Command. The study members and participants are listed in the Appendix.

This study was chartered by the Air Force Chief of Staff, General Ronald Fogleman, with cognizant oversight provided by the Assistant Secretary of the Air Force for Acquisition, Lt Gen George Muellner. the study charter was to:

> *Establish a Vision of aerospace command and control for the 21st century by evaluating the current state of C2 and developing a migration strategy and process improvements that will allow movement from the current status toward that Vision.*

This study was done during April and May of 1996 and culminated during the SAB Summer Study held at the National Research Council Beckman Center in Irvine, CA between 17 and 28 June 1996.

The study effort was organized into five panels with joint SAB and Air Force membership. These panels were: C2 Philosophy, Current C2, Vision, Migration Strategy, and Process Improvements.

Command and Control Philosophy

Though not always recognized explicitly, C2—the act of leading and directing the resources assigned to a military commander—is fundamental to military operations. For reasons illuminated in this study, the present national and global situation places an unprecedented importance and demand on C2 and the systems that support it.

The end of the Cold War has left the US military with an enormous challenge of adaptation. That challenge derives from several conditions outlined below.

¥ The decreased military strength of the former Soviet Bloc and the victory in Desert Storm present a “post war” climate in Congress and the populace that expects a smaller, less costly military force.

¥ Being the only global superpower means that the number of instances in which US forces might be called into play actually increases over that experienced during the Cold War.

¥ With such global responsibility, the smaller force must still reach anywhere, anytime, and more likely, from bases within CONUS.

¥ The type and degree of hostilities now range wider than ever—from major regional conflicts to large, sometimes threatening, humanitarian missions.

¥ An increase in the use of small insurgent, guerrilla, and terrorist forms of warfare, plus the availability of small but very lethal weapons, require an increasing need for rapid and precise response.

¥ The political and economic interests on which US forces may act are less predictable.

Thus, a broader range of military and humanitarian missions, stretched over an increased global area in a more responsive time frame but with substantially fewer resources, is an extraordinary challenge. Success in this environment requires maximum utilization and performance from each element of the overall force. That can only be done with a jointly integrated, ubiquitous, and responsive C2 support system. That system must provide a far greater knowledge of the battlespace than one's enemy has and enable the command and direction of all aspects of operations continuously from anywhere. This report provides a vision of how an increased understanding of the battlespace and a vastly electronic integration of our resources can form an air component that projects overwhelming and decisive power using far fewer resources.

The global political and economic factors coupled with US domestic factors have created a set of conditions which will have significant impact on Air Force global operations and the C2 systems that enable them. These factors demand a C2 system that can support operations effectively in constrained environments across a spectrum of conflict in many geographical areas, sometimes simultaneously. Some of these factors and conditions are summarized below.

¥ The shrinking DoD budget and changes in US military strategy are resulting in a largely CONUS-based force. At the same time though, the sphere of US interests continues to expand.

¥ Joint and coalition operations will be the norm, not the exception.

¥ Many operations may be simultaneous and widely dispersed geographically. In these situations, interoperability will be essential, particularly C2 interoperability.

¥ Regional access to facilities and communications may not be easy or at least as extensive as that available in CONUS. The infrastructure available to support operations may be limited. This is further complicated by the need for smaller forward deployments. The C2 system must be modular to enable tailoring for specific use with a minimum logistics footprint.

¥ The ability to understand what is occurring in the battlespace has made the Air Force aware of C2-imposed limitations on combat effectiveness. As a consequence, the true potential of aerospace power has not been completely realized.

¥ Aerospace power will be called upon to rapidly move military equipment, people, and supplies worldwide. Missions will range from isolating the battlefield in one part of the world and providing information to forces in another. At the same time, aerospace power must be prepared to fight a major regional conflict anywhere in the world.

¥ Aerospace power will be the option of choice for many dimensions of conflict.

¥ The development and procurement of an agile, affordable C2 system to support future operations depends on the Air Force's ability to easily and routinely incorporate commercial technology. The current Air Force requirements and acquisition process is not fast or flexible enough to permit this routinely—change is needed.

These conditions have made the inefficiencies and cost of the current C2 systems intolerable; in fact, aerospace power is seriously handicapped by today's C2 system. The power of precision weapon delivery and target attack and the ability to respond rapidly to and in any contingency are all inhibited to varying degrees today. Aerospace C2 for the next century must be designed to remove these shackles in order to unleash the total capability that aerospace power possesses.

The Air Force must develop and evolve its C2 systems to allow the fundamental capabilities embodied in Aerospace Power to be realized in the conduct of future missions in support of the Joint Task Force Commander's needs. These systems must have the following attributes and capabilities.

¥ Enhanced decisionmaking tools which enable the decision maker to solve multi-dimensional, time-sensitive problems.

¥ Increased efficiency by allowing the operator to accomplish the task better, quicker, and with fewer mistakes by,

⇒ providing information to the decisionmaker sooner,

⇒ allowing Commanders to operate from the same knowledge base for common understanding of the battlespace situation,

⇒ making information available, through integration, interoperability, and tailorable releaseability to all operators for improved mission success,

⇒ allowing flexibility to employ aerospace power across varying conflicts and differing levels of delegated authority,

⇒ tailoring the information for mission and resource needs (rapid deployability enables split base operations),

⇒ allowing the use of existing commercial infrastructures, where logical and reliable,

⇒ allowing "plug and play" capability for quick and effective response to any operation,

⇒ allowing for decisions based on a mission to task relationship, not a technology relationship.

With these new capabilities, the Air Force will be in a position to develop C2 concepts almost unconstrained by technology. For if the technology is not here today, the rapid pace of technological advancement almost guarantees it will be here tomorrow. The establishment of the C2 Vision is an attempt to bring together complementing services to aid the decisionmaker. All contain a major piece of the Commanders' necessary knowledge base, and without combining them, the information will be fragmented and unintelligible.

Current Command and Control Systems

During the course of the study, functional and systems architecture models were reviewed for all C2 systems and sensors. An analysis was conducted on the flow of authority between C2 echelons during Bosnia, Desert Storm, Haiti, and Korea. An analysis was conducted on the tasks required for Defensive Counter Air (DCA), Close Air Support (CAS), Interdiction (INT) for mobile and fixed targets, Airlift, Offensive Counter Air (OCA), and Strategic Attack missions. Further assessments were conducted on the current relationships, tasks, and levels of authority between C2 and sensors and C2 and shooters during these missions.

During the analyses, the study panels assessed patterns associated with the specific command and control tasks in a variety of operations and authority relationships. These ranged from peacekeeping operations in Bosnia and Haiti on one hand to major regional conflicts on the other. These analyses demonstrated that the fundamental tasks required for C2 are essentially the same over the range of missions, variations in authority flow, and phases of conflict. The Air Force understands how to execute command and control and to date has executed it effectively for all missions over all stages of conflict. This was effectively demonstrated during Operation Desert Storm and in Bosnia.

The conclusion is that the fundamental structure of C2 is not broken. However, the process of C2 could be made more efficient and effective over a broad set of missions by the application of information technologies which can extend the range of operation and reduce the latency from observation to execution. Range and speed of communications shortfalls exist for some missions, particularly those requiring long-range operations against time-critical targets. When analyzed against missions, the panels found many C2 similarities between the tasks required when conducting DCA and INT against mobile targets. The C2 structure was designed to work in close proximity to forces (friend and foe) for DCA and CAS and was not designed to reach deep into enemy territory, particularly for time-critical targets.

The Air Force Core Competencies of Global Presence, Reach, and Power are outpacing their C2 systems. Today, the C2 system is piecemealed each time a conflict arises. Capabilities are strung together in order to give the Commander the best look available, and this is not the most efficient way to fight a war. It is obvious that manual decision processes and line of sight communications are inadequate for effective mission execution.

Information technologies when properly applied, can increase C2 efficiency and effectiveness. The Commander's ability to observe, orient, decide, and act can be greatly enhanced if future C2 systems can:

¥ provide theater-wide sensor data, fused together for a clearer understanding of the operational situation,

¥ provide this information to decision support tools to add center of gravity analysis covering strategic, operational, and tactical, including both friend and foe,

¥ provide modeling and simulation capability for execution analysis to "fly the missions ahead of time,"

¥ provide robust communications with over-the-horizon connectivity to extend operations and the Commander's control both into and out of the theater and into and out of the cockpit,

¥ be employed with fewer people and less time, support tail, and airlift, facilitating rapid deployment and operations.

Vision

The Air Force has proven its ability to successfully conduct large-scale air operations in support of a joint theater campaign, to carry out humanitarian airlifts worldwide, and to meet special needs such as the emergency evacuations of US and other citizens in danger. Despite these successes, it has become obvious that to continue to do these and a host of new missions well, with increasingly fewer resources, requires C2 support systems of much greater awareness and precision, more complete and continuous connectivity, and compatibility across the joint military structure.

As a result the Air Force needs to begin an intensive effort to improve its current C2 systems. By taking advantage of the opportunities technology will provide, the Air Force can significantly improve the way it executes C2 on a global basis. We must provide a vision of how an increased knowledge of the battlespace and a vastly enriched and more complete electronic integration of our resources can leverage our air component assets and still project overwhelming land, sea, and air power.

The Vision for the future command support systems is:

> *Global command and control of aerospace forces throughout the spectrum of military operations by exploiting information to know, predict, and dominate the battlespace.*

The mission associated with executing this Vision is to:

> *Engage aerospace forces to observe, shape, and affect the battlespace and to operate these forces in a joint or coalition environment as directed.*

Given this Vision and mission, a number of attributes of future C2 systems are needed to achieve effective global C2 across the full spectrum of military operations. This list includes the ability to (a) gather and create information that enables global awareness and situational knowledge, (b) enable operations beyond the horizon, (c) provide low forward logistical footprints with rapid and automatic resupply, (d) provide a consistent and ubiquitous infrastructure, (e) offer the flexibility and redundancy of virtual command centers, logically integrated but physically separated, (f) provide a common logical database accessible to authorized users, and (g) enhance decisions via automated decision tools. These items are all discussed in detail in four basic parts. The first three parts discuss the C2 system of the future from an operational perspective: (a) Global Awareness, (b) Dynamic Planning and Execution Control, and (c) Routine Over-the-Horizon Operations. The fourth part discusses C2 support from a systems point of view and how it will meet operational needs.

Global Awareness—that portion of the vision statement dealing with "...exploiting information to know, predict, and dominate the battlespace"—is accomplished only through an ability to consistently "out-know" your enemy. The ability to precisely know and target an enemy more quickly than he can react will be a fundamental attribute for all future conflicts and thus C2 systems. From an operational viewpoint, superior situational awareness requires that our information sources give near-real-time and near-perfect knowledge, each good enough to do something militarily significant. It must be available for all relevant military operational areas, with sufficient geo-location precision to accomplish the task at hand. Global awareness must also ensure that relevant military objects, both friendly and enemy, are quickly determined from real-time battlespace surveillance, rapid battle damage assessment, and self-reporting of friendly forces and materiel.

Dynamic Planning and Execution Control is the second major area in the improvement of future C2 systems and addresses the intelligent use of the relevant knowledge acquired in global awareness to plan and execute missions. The planning portion of the system must operate in a nonlinear, asynchronous, and interactive manner. The necessary mobility and logistics actions become an automatic part of planning and execution. All appropriate military objects, along with the target queue, are inserted into a planning model. Selection is based on such things as CINC/JFACC campaign objectives and rules of engagement, coalition inputs, weather, and faster-than-real-time simulations for understanding the impact of decisions.

As the target queue is dynamically built, it is also dynamically executed to match weapon systems and targets, and even to dispatch the weapon (air, space, land, sea, info). The execution of the target queue can be by an attack controller that can be located anywhere, in the air, on land, at sea, or even outside the theater of operations. The final step of the mission (although it never stops) is to update the battle space picture.

The dynamic planning and execution cycle is a continuously repeating process of building the picture, developing the target queue, prosecuting the queue, and updating the picture. Even humanitarian missions have their objective targets.

Over-The-Horizon (OTH) activities, the third area, must become routine and eliminate the current dependency on line of sight communications. Activities and conditions in the first two areas will force reliance on OTH communications and connectivity as will such needs as remote information collection, sensor control, responsive automatic logistics to minimize large and vulnerable theater deployment, reach back, in-transit visibility, and weapon system targeting and retargeting while enroute, anywhere on the globe.

To successfully accomplish these OTH activities there must be (a) connectivity to all platforms—anywhere, anytime—as a necessary condition, (b) communications bandwidth appropriate to the task and available when and where needed, (c) flexibility in the location and mobility of command support facilities for protection and maximum capability, and (d) a communications system that will react quickly and accurately to help produce the desired military outcomes in the minimum time.

To summarize, the expectation of this new C2 system is that it will function across the spectrum of military operations, require a global awareness and a detailed knowledge of the battlespace, and use dynamic planning and execution control to fight the war. Over-the-horizon operations must be as natural as line of sight. Given this operational view of the Vision for the C2 system of the future, what does the corresponding support system, the fourth part that makes it all happen, need to look like for faithful implementation?

To give the future C2 system the flexibility it must have, we model it in two major parts with two layers in each part. This model shows the relationship between the functions of command and the characteristics of its support systems. One part is a flexible set of tools and information, adapted only where necessary, to the specific conflict or mission in question (command support applications and supporting database), and the other part is invariant across space and the spectrum of conflicts. This second part consists of a common, consistent, and ubiquitous infrastructure; that is, a common computing environment and a global communications utility on which to build and operate a wide range of tools and to provide command-relevant information, irrespective of the mission, time, or location.

By using this model, the report discusses how each layer builds upon the next to enable execution of the future C2 vision while identifying the attributes and features of the layers' relationships with each other, critical technologies necessary for implementing the layer, and each's contribution to the C2 system as a whole. While each layer can be discussed in isolation, they must all work together for a total C2 system solution.

In summary, the command support applications provide the software that implements the operational requirements and functionality. The database houses any and all information in a multitude of formats (text, video, etc.) needed by the applications to support global awareness and dynamic planning and execution. It will be physically distributed but be logically integrated. The common computing environment consists of operating systems, common utilities, and other common attributes such as the GCCS Common Operating Environment. The final layer, the communications utility, is the linchpin that holds all resources together. As the bottom layer of the model it must provide a wide range of communications capabilities and services across multiple transmission media to achieve total connectivity.

Given this vision and system model, a number of issues relating to the C2 system such as we have described must be analyzed and answered. Many of them can and need to be addressed through the development and migration of systems and products through Advanced Concept Technology Demonstrations (ACTDs), especially for those items that will not be commercially developed.

Migration Strategy

As a means of taking “the first step” toward achieving the Vision discussed above, we have posed a collection of actions to address today’s shortcomings that would, in turn, begin the migration to that future. This migration path establishes ground rules and sets the course toward the Air Force 21st Century Vision of Command and Control.

The migration strategy focuses on ACTDs to “jump start” operations concept development in concert with developing technologies. We have linked selected ACTDs to specific Air Force C2 systems with top-level program objectives that would be adjusted by the ACTDs’ progress. Furthermore, we have identified general opportunities for costing offsets. Additionally, we feel it imperative that conceptual understanding of what new technologies have to offer the warfighter is just as critical to success as the technologies themselves.

The major thrusts of the migration strategy address improvements in command and control, communications, reconnaissance and surveillance platform ‘right sizing,’ data warehousing, and integrated command center information fusion and display.

Communications Infrastructure. Three specific ACTDs address communications infrastructure shortfalls while setting the initial path toward specific objectives of the Vision.

ACTD	Shortfalls	Objectives
Speakeasy	Costly, stovepipe radio waveform processing	Flexible, adaptive communications
Global Hawk Comm Relay	Line of sight limitations; SATCOM overload	OTH “Global” Connectivity; download space to more efficient use
Information Grid	Poor channel and bandwidth allocations; data “stovepipes	Right info, to right warrior, at the right time; smart data-rate management

Specifically, we recommend employment of software programmable “radio” equipment, similar to that developed under the SPEAKEASY program at Rome Laboratory as a substitute for new avionics and ground equipment. SPEAKEASY would replace Link 16, UHF DAMA SATCOM, IDM, and other “stovepiped,” single function systems with a radio capability that can be programmed to accommodate a number of mission modes. The SPEAKEASY technology can provide mode-selectable emulation of VHF SINCGARS, UHF HAVEQUICK, various tactical datalinks (TADILS), and more. By applying a more flexible software programmable signal processing technology, platform mission communications and signal processing can be tailored to specific mission needs rather than restricted by limited, legacy avionics and overloaded bus architectures.

A second ACTD leverages the GLOBAL HAWK uninhabited aerial vehicle (UAV) payload capability, commercial SATCOM links, and the SPEAKEASY technology to field a flight of communications relay UAVs. From their theater ranging operation altitude of 65,000 feet, GLOBAL HAWK with its multi-channel, software programmable communications payload could be tasked to extend the range of forward air controller communications and air ground communications well beyond line of sight. With appropriate antenna configurations, the SPEAKEASY can relay VHF FM, UHF AM, SINCGARS, HAVE QUICK, and Link 16 communications among widely separated forces. The UAV relay provides an in-theater pseudo-satellite that is directly responsive to warfighter needs. The rapidly reconfigurable SPEAKEASY radios can be switched from mode to mode as the need arises. Utilizing SATCOM connectivity links can be extended into the Defense Information Systems Network for worldwide communications grid access or to provide theater reach-back access. Additional development would add Milstar Medium Data Rate waveforms to the UAV relay, providing a surge communications relay for Army Mobile Subscriber Equipment (MSE) range extension and supplementing limited Milstar channels. The utility of the UAV relay allows operational commanders to provide ABCCC-like C2 functions from garrison locations.

A final communications ACTD explores how the variety of battlefield communications services ranging from commercial SATCOM, cellular, telephone, fiber optic, high frequency radio, etc., can be combined into a single, seamless information grid. It specifically addresses the unique vulnerabilities of various communications media and explores the methods that can be used to mitigate and manage these vulnerabilities to obtain the seamless C2 infrastructure warfighters are demanding. This ACTD could put the Air Force in the lead implementing roll in the JCS J-6's *C4I For the Warrior* vision as well as focus DARPA's *Broad Area Data Dissemination* project to Air Force needs.

Programs directly benefiting from (and paying for) the technology and operational concept advancement of the ACTDs would include large airborne sensor platforms, ABCCC avionics programs (including IMA), MILSATCOM, and C2 interoperability of shooter platforms.

<u>Large C2, Surveillance, and Reconnaissance Platforms</u>. Changes to the missions of large C2, surveillance, and reconnaissance platforms are proposed in an ACTD with the following shortfalls and objectives addressed.

<u>ACTD</u>	<u>Shortfalls</u>	<u>Objectives</u>
Large C2, Surveillance, and	Costly, Vulnerable, Inflexible systems;	Flexible, adaptive, mission tailored sensor systems. Connect decisionmakers to the

Reconnaissance Platforms	human in harm's way; inefficient data processing	information vs. the platform

We recommended that the operator consoles and sensor operator crews that normally man large sensor platforms be off-loaded to ground or "safe area" air/sea facilities and the sensor consoles remoted off-board. Advancing the concept of connecting the people to the information, rather than just putting them on the platform, could demonstrate that the remotely controlled sensor could be more effective than relying solely on manned sensors.

Operational issues such as flexible "capsule" crew duty that coincides with sensor and mission workload adjustments, use of powerful sensor fusion and data correlation systems, and more cost-effective mission platforms could be explored. Thus, the sensor payloads could be downsized or 'right sized' based on the sensor requirements. If necessary, the additional payloads can be used to increase on-orbit endurance or provide additional payloads needed to enhance mission capability. We recommend Rivet Joint as an initial demonstration since U-2 and other space/airborne platforms provide a template upon which to build the Rivet Joint demonstration and regional SIGINT Operations Centers provide likely hosts for mission crews.

Data Warehouse. In a third area, we have recommended an ACTD to demonstrate the feasibility of applying data warehouse technologies to the battlespace information problem.

ACTD	Shortfalls	Objectives
Data Warehouse	Stovepiped systems, "data deluge," lack of references and correlations; multiple "fat finger entries"	Geospatial and time tagging methods to assist correlation and fusion, harness massively parallel and distributed systems

Specifically, we have recommended that a repository for data be developed and fielded. The formatting, collection, safeguarding, distribution, and storage of data for ready accessibility by all potential users was seen as a step toward addressing some of the shortfalls in battlespace awareness. The objective of this ACTD would be to provide a "one stop shop" process for battlespace data in a system that could be updated by the responsible data owner and be simultaneously available to any authorized user in the battlespace.

JFACC After Next. In the final ACTD recommendation, we advocate that the USAF take active ownership of the DARPA "JFACC After Next" ACTD.

ACTD	Shortfalls	Objectives
JFACC After Next	Ad hoc "system" construction,	Adaptive, mission-tailored, distributed system; commercial technology leverage, modeling and

	monolithic, "stovepiped" software systems	simulation support to decision making; prosecute short-dwell targets; responsive damage assessment

By providing leadership, direction, and cooperative funding for this ACTD, it could serve as a means of demonstrating the fusion and information integration necessary for future command and control. The panel specifically highlighted the need for a JFACC decision support tool kit that would facilitate split-based operations and provide the type of collaborative tools that would allow virtual interaction for a compendium of military missions. The ongoing DARPA effort was seen as the principle near term effort that could be leveraged to demonstrate the type of future C2 system envisioned for the USAF in the next century.

The migration strategy must be undertaken within the boundaries of a process that affords operators at all levels active participation in design, development, and evolution of the C2 system. Thus, we have proposed a significant change for evolutionary development in the form of ACTD "first steps," in which operators are coupled with developers at every step of an evolving process. We believe that the ACTD projects proposed in this report could move the Air Force in the right direction while providing flexibility to adapt to future expectations. To meet the Airpower C2 needs of the 21st century, the Air Force must begin its movement now.

Process Improvements

The Air Force needs to institutionalize a process to assure it can rapidly exploit technology advances as it continues to modernize its C2 systems. The report discusses the problems with the current process and the needs that the process must meet to successfully implement and sustain the vision. It also recommends the Air Force create a C2 Enterprise to institutionalize the changes needed in requirements, PPBS, technology, acquisition, training, organization, and doctrine.

The most obvious symptom of the problem is that the C2 system is reinvented every time a new operation is engaged: Desert Storm and Bosnia both illustrate this point. While tailoring C2 to the unique requirements of an operation is a necessity, most of the effort is spent re-engineering how the collection of C2 tools are connected and integrated, trying to achieve an acceptable degree of interoperability. Since the resulting configuration and operational workarounds are unique, C2 training is inadequate. This results in an unacceptably long time to achieve an operational capability in theater and difficulty in sustaining an efficient C2 operation with trained personnel. Perhaps the most significant obstacle to supporting the JFACC with a tailorable, interoperable C2 system is rooted in the approach to equipping and provisioning for C2. Interoperability problems are often blamed on stovepiped acquisition or operations. But stovepiping of C2 systems begins much earlier than acquisition or operations. Systems are stovepiped from the very beginning in terms of how they are defined, funded, advocated, and managed by the Air Force. This stovepiping problem extends to the very core of how our forces are equipped. Without an integrated C2 system, a limited capability exists to allow an assessment of the value that a new capability might bring to an operation. Consequently the Air force finds itself with an almost infinite list of "could do's" with limited means for determining what it "should do." This decisionmaking paralysis at the requirements level, combined with funding and acquisition inefficiencies, makes the timely insertion and fielding of new C2 capabilities the exception rather than the rule.

To address these problems the Air Force should restructure its corporate process for modernizing C2 to meet the following needs.

¥ Consolidate and integrate mission needs for conducting C2 in a joint and coalition environment.

¥ Focus the corporate Planning, Programming, and Budgeting System structure on advocating and managing an integrated C2 program.

¥ Develop a methodology and tools to determine the value of new capabilities.

¥ Be able to rapidly select, mature, and field new C2 capabilities.

¥ Organize, train, equip, and provide for common C2 across the Air Force.

¥ Continually evaluate and evolve C2 operational concepts and doctrine.

To meet these needs we recommend the Air Force create a C2 Enterprise area to focus leadership and resources on C2. The C2 Enterprise approach defines C2 as an integrated weapon system and uses this as a unifying theme to manage and integrate C2 across the Air Force. The Enterprise has two basic thrusts. First is to break down the requirements and funding stovepipes by establishing a corporate-level operational advocate for C2 who is responsible for integrating C2 strategic planning, requirements, and financial planning across all mission areas, as well as advocating cross-cutting C2 needs. Second is to implement an evolutionary requirements and acquisition process which allows rapid technology insertion and drives the evolution requirements and doctrine to make the maximum operational use of new opportunities.

Establishing a corporate-level focus for C2 requires establishing a board of directors to oversee the Enterprise. A C2 General Officers Steering Group (GOSG), chaired by the Air Staff operational advocate for C2 with membership from the MAJCOMs and other Air Staff and Secretariat personnel, would function as that board of directors. The GOSG would oversee the strategic planning, requirements development and integration, financial planning, and technology planning functions for C2. Strategic planning will sustain the long-term vision for C2 and maintain a long-term investment strategy and migration plan which integrates aerospace mission needs for AF and Joint users. Requirements should be integrated into a Capstone Requirements Document which would define overarching C2 requirements, a general architecture for the C2 system and top-level requirements for each mission area and establish the aerospace-unique functions required in the DII COE. Financial planning must be focused into a single resource allocation panel in order to give the GOSG visibility into how all types of funding are supporting C2 and for C2 capabilities to compete against other warfighting investments rather than having individual components of the system competing independently, often against other C2 system components. Technology planning must recognize that the commercial sector drives most of the technology C2 requires and look for opportunities to partner with industry to provide military-unique functionality within commercial products.

The C2 Enterprise should institutionalize an evolutionary process built upon the spiral evolution model exemplified by how the Internet evolution is managed. The process continually solicits and assesses new technologies and needs, matures and selects capabilities with operational benefit, and provides a mature capability to the C2 system for incorporation into fielded systems. This process is the “engine” which drives the evolution of C2 requirements, systems, operational concepts, and doctrine. The throttle for this engine is the GOSG, with a supporting O-6 advisory group and integrated product teams. The critical enabler of this process is to provide the GOSG structure with a recapitalization fund in order to invest in promising concepts and technologies. We strongly recommend that decisionmaking and authority to commit funds to a new idea be delegated as far down in this organization as possible in order to maintain a rapid and vibrant evolutionary engine.

The Enterprise engine must be supported by an infrastructure which will evaluate, mature, and test new technologies, concepts, and procedures. This infrastructure is envisioned to entail a Battle Lab, which supports a range of evaluation capabilities from analysis and modeling through prototype demonstrations, combined testing in the battle lab environment, operational evaluations and exercises. It also requires a System Engineering and Integration organization to support technical evaluation, test, and integration of concepts and technologies, and a demonstration facility in the National Capital Region to support the GOSG and demonstrate Air Force C2 capabilities to decision makers in DoD and Congress.

The evolutionary approach takes new ideas, whether they represent responses to deficiencies, new needs, or new opportunities, which are evaluated by the GOSG structure and which can be funded for the purposes of exploration and maturation. Depending upon the maturity and scope of the concept, the GOSG would select an appropriate evaluation path and investment. The evaluation is implemented through the engine infrastructure, and results provided back to the GOSG structure. This select, evaluate, and mature process would continue as long as the proposal continues to show promise and ultimately ends when it is ready for fielding. At any point the proposal may also be terminated if it is not maturing or has been superseded by a competing technology or idea.

Several Air Force processes must be streamlined in order to support the evolutionary approach. Requirements should not be formally validated until a capability is ready for fielding. This allows the capability to be evaluated and matured in parallel with the requirements validation process which currently takes months or years. The acquisition process should use the evolutionary engine to support the solicitation and source selection process to insure competition requirements are met without going through a multi-month/multi-year solicitation and source selection process. It should establish an "open-ended" request for proposal to solicit ideas from industry and use the evolutionary engine for competing these ideas and capabilities as they mature. Contracting approaches must establish mechanisms for rapidly procuring commercial products. Testing can be streamlined by using the evolutionary process to address development and operational test issues in parallel.

Information technology skills will become essential for every member of the Air Force. All accession training programs should include the fundamentals of information systems and basic computer skills. The Battle Lab will be a critical training resource and must support all levels of training, from the accession level, through specialty, recurring, and certification training and service, joint, and coalition exercises. Training must be embedded in the C2 system, with the ability to exercise a new capability, then reconfigure to an operational mode being a fundamental requirement. Finally, the Air Force personnel system must identify, manage, and retain people who have C2 experience and skills. At some point, experience as a member of the C2 weapon system operational team may become a prerequisite for senior command positions.

The Air Force should take the following first steps to initiate the C2 Enterprise immediately:

¥ Create an Air Staff-level organization within XO with responsibility for C2.

¥ Charter a C2 GOSG as the C2 Enterprise board of directors.

¥ Integrate financial planning into a single resource panel.

¥ Start a C2 strategic planning function.

¥ Establish funding for the engine infrastructure.

¥ Build a prototype evolution process.

¥ Establish a demonstration facility in the National Capital Region.

Appendix

Study Participants

Name	Affiliation
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Col B. Queen	SAF/AQPC
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Appendix C Technology Roadmap for Vision

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List of Acronyms

Acronym	Definition
ABCCC	Airborne Battlefield Command and Control Center
ACC	Air Combat Command
ACO	Airspace Control Order
ACID	Advanced Concept Technology Demonstration
ADA	Air Defense Artillery
AFCC	Air Force Component Commander
AFMSS	Air Force Mission Support System
AGA	Ah to Ground to Air
AOC	Ah Operations Center
AOR	Area of Responsibility
ASOC	Air Support Operations Center
ATCALS	Air Traffic Control and Landing System
ATM	Air Tasking Message
AT0	Air Tasking Order
ATR	Automatic Target Recognition
AWACS	Airborne Warning and Control System
BADD	Battlefield Awareness Data Dissemination
BDA	Battle Damage Assessment
BES	Budget Estimate Submission
BII	Base Information Infrastructure
BLOS	Beyond Line of Sight
BoD	Board of Directors
BSD	Battlefield Situation Display
c2	Command and Control
C2IPS	Command and Control Information Processing System
c3	Command, Control and Communications
CAOC	Combined Air Operations Center
CAPS	Consolidated Aerial Port System
CARS	Contingency Airborne Reconnaissance System
CAS	Close Air Support
CCPL	Command Center Product Line
CDL	Common Data Link
CID	Combat Identification
CIS	Combat Intelligence System
COE	Common Operating Enviromnent
COMINT	Communications Intelligence
CONUS	Continental United States
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off the Shelf
CRC	Control and Reporting Center
CRD	Capstone Requirements Document
CRE	Control and Reporting Element
c s	Constant Source
CTAPS	Contingency Theater Automated Planning System
DAMA	Demand Assigned Multiple Access
DARPA	Defense Advanced Research Projects Agency
DBS	Direct Broadcast Satellite
DCA	Defensive Counter Air
DII	Defense Information Infrastructure

DMSP	Defense Meteorological Satellite Program
DoD	Department of Defense
ECCM	Electronic Counter Counter Measure
EHF	Extremely High Frequency
ELINT	Electronic Intelligence
EPLRS	Enhanced Position Location Reporting System
ESC	Electronic Systems Center
Ew	Electronic Warfare
FAC	Forward Air Controller
FAC(A)	Forward Air Controller (Airborne)
FANS	Future Air Navigation System
FLIR	Forward Looking Infrared Radar
FM	Frequency Modulation
FOA	Field Operating Agency
GBS	Global Broadcast Service
GCCS	Global Command and Control System
GDSS	Global Decision Support System
GOSG	General Officer Steering Group
GPS	Global Positioning System
GWC	Global Weather Central
HF	High Frequency
HFSSB	High Frequency Single Side Band
IBS	Integrated Broadcast Service
IDM	Integrated Data Modem
IFF	Identification Friend or Foe
ILS	Integrated Landing System
IMA	Integrated Modular Avionics
INT	Interdiction
IPT	Integrated Product Team
JCS	Joint Chiefs of Staff
JFACC	Joint Force Air Component Commander
JMCIS	Joint Maritime Command Information System
JPT	JFACC Planning Tool
JSAS	JFACC Situational Awareness System
	Joint Situation Awareness System
JSTARS	Joint Surveillance Targeting and Attack Radar System
JTF	Joint Task Force
JTIDS	Joint Tactical Information Distribution System
LES	Leading Edge Services
LO	Low Observable
LOS	Line of Sight
LPD	Low Probability of Detection
LPI	Low Probability of Intercept
MAJCOM	Major Command
MAP	Mission Area Plan
MCE	Modular Control Element
MDR	Medium Data Rate
MILSATCOM	Military Satellite Communications
MOE	Measure of Effectiveness
MOP	Measure of Performance
MRC	Major Regional Conflict
MRCI	Modular Reconfigurable C2 Interface
MSE	Mobile Subscriber Equipment
MSP	Mission Support Plan

NASM	National Air and Space Model
NCA	National Command Authority
NCR	National Capital Region
NEO	Non-combatant Evacuation Operations
O&M	Operations and Maintenance
OB	Order of Battle
OCA	Offensive Counter Air
OODA	Observe, Orient, Decide, Act
OOTW	Operations Other Than War
OTH	Over The Horizon
PLRS	Position Location Reporting System
POES	Polar Orbiting Environmental System
PPBS	Planning, Programming, and Budgeting System
R&D	Research and Development
REMIS	Reliability and Maintainability Information System
ROCC	Regional Operations Control Center
ROE	Rules of Engagement
RSOC	Regional SIGINT Operations Center
RTIC	Real Time Intelligence to the Cockpit
RWR	Radar Warning Receiver
S&T	Science and Technology
SAB	Scientific Advisory Board
SADL	Situational Awareness Data Link
SATCOM	Satellite Communications
SBIRS	Space-Based Infrared System
SCDL	Surveillance and Control Data Link
SHAPE	Supreme Headquarters, Allied Powers Europe
SIC	Systems Integration Center
SINCGARS	Single Channel Ground to Air Radio System
SOCC .	Sector Operations Control Center
SOF	Special Operations Forces
SPO	System Program Office
SWPS	Strategic Warfare Planning System
TAC	Terminal Attack Controller
TACP	Tactical Air Control Party
TBM	Theater Battle Management
TBMCS	Theater Battle Management Core System
TDC	Theater Deployed Communications
TEL	Transporter/Erector/Launcher
TIBS	Tactical Information Broadcast Service
TICCARS	Tactical Interim CAMS/REMIS Reporting System
TPIPT	Technical Planning Integrated Product Team
TRAP	Tactical and Related Applications
TTP	Training and Transfer Plans
UAV	Uninhabited Aerial Vehicle
UHF	Ultra High Frequency
u s	United States
USAF	United States Air Force
VHF	Very High Frequency
WCCS	Wing Command and Control System
WMD	Weapons of Mass Destruction
WOC	Wing Operations Center

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Chapter 1

Command and Control Philosophy

1.1 Introduction

Though not always recognized explicitly, command and control (C2), the act of leading and directing the resources assigned to a military commander, is fundamental to military operations. For reasons illuminated in this study, the present national and global situation places an unprecedented importance and demand on C2 and the systems that support it.

The end of the Cold War has left the US military with an enormous challenge of adaptation. That challenge derives from several conditions outlined below:

- The decreased military strength of the former Soviet Bloc and the victory in Desert Storm present a "post-war" climate in Congress and the populace that expects a smaller, less costly military force.
- Being the only global superpower means that the number of instances in which US forces might be called into play actually increases over that experienced during the Cold War.
- With such global responsibility, the smaller force must still reach anywhere, anytime, and, more likely, from bases within CONUS.
- The type and degree of hostilities now range wider than ever-from major regional conflicts (MRCs) to large, sometimes threatening, humanitarian missions.
- An increase in the use of small insurgent, guerrilla, and terrorist forms of warfare, plus the availability of small but very lethal weapons, requires an increasing need for rapid and precise response.
- The political and economic interests on which US forces may act are less predictable,

Thus, a broader range of military and humanitarian missions, stretched over an increased global area, in a more responsive time frame but with substantially fewer resources is an extraordinary challenge. Success in this environment requires maximum utilization and performance from each element of the overall force. That can only be done with a jointly integrated, ubiquitous, and responsive C2 support system. That system must provide a far greater knowledge of the battlespace than one's enemy has and enable the command and direction of all aspects of operations continuously from anywhere. This report provides a vision of how an increased understanding of the battlespace and a vastly electronic integration of our resources can form an air component that projects overwhelming and decisive power using far fewer resources.

But the ability to "out-know" an enemy enables success only if our forces can respond in time. To observe, understand, and ultimately react to an enemy's vulnerability while he is still unaware is the powerful leverage of an information-dominant approach to battle. To orchestrate a remote mission where minimal resources come together with precise timing and targeting, yet whose impact is irrecoverable, takes highly refined C2 planning and execution tools. Our joint forces presently have neither the awareness, the integrated connectivity, nor the responsiveness to exert this leverage on the future battlespace.

1.2 Military Environment

The dramatic economic and political changes have produced a radically different environment in which the US Armed Forces must be prepared to operate in the future. Gone are the days of single adversary focus, which produced a sense of security (real or imagined) for military planning. With no single specific threat in the world at the current time, the US is unable to predetermine the geographical location of adversaries and therefore cannot preposition forces. MRCs are more predictable and easier to plan, but Operations Other Than War (OOTW) are less predictable and therefore more difficult to plan.

Future crises will unfold rapidly, allowing little planning time. An established Operations Plan scenario is unlikely. There will be no tune for additional force training; the "come as you are" concept will become mandatory. Force structure reductions and redeployments have reduced force deployment and response flexibility to meet changing global challenges. This requires the US to project its military power from the CONUS during both active contingencies and peace maintenance efforts. These changes have had an impact on every facet of US military operations, with C2 being the functional area that underwrites the military's capability to take the right action, in the right place, at the right time.

Potential conflict situations now range from peace enforcement, to humanitarian aid under attack, to non-combatant evacuation operations (NEOs), to MRCs. For the Air Force, this translates to operations ranging from isolating the battlefield, to providing information to support US and indigenous forces, to global mobility, to all out war for which the Air Force may be the first choice of combat power. Decisions to engage will be influenced by politics and economic issues, often resulting in highly constrained Rules of Engagement (ROE).

Tomorrow's warfare will be shaped by a high-operations tempo in which the Observe, Orient, Decide, and Act (OODA) loop will be compressed to ensure it will operate faster than the enemy's OODA loop. In addition, the amount of information needed to support these compressed OODA loops is increasing at exponential rates, The'need for information at the point of action is growing rapidly due to the implementation of standoff and smart weapons and the need for real-time battle damage assessment and dynamic situational awareness.

The conflicts in Southwest Asia, Somalia, Bosnia, and Haiti demonstrated that information technology has significantly altered traditional concepts for military operations. That same technology is improving situational awareness on a global scale and augmenting the ability to generate military options before a crisis can erupt. Once military force becomes necessary, information technology provides numerous options for prosecuting the conflict.

The Air Force will enter the 21st century with approximately one-half the force structure it had during Desert Storm, less overseas support infrastructure, increasingly smaller acquisition and operating budgets, more regional threat interests, and near-real-time global response requirements. Effective and timely application of the Air Force's inherent attributes of range, speed, flexibility, and long-range precision weaponry against a global array of potential adversaries will depend on the effectiveness of its C2 assets. In many cases, these adversaries will have access to weapons and information systems that match or exceed the capabilities of US and coalition forces. C2 must support the commander's need for knowledge-based decision making.

1.3 Focus on the Commander

C2 begins with an understanding of both the responsibilities of command and the nature of warfare. There are real and important distinctions between the process of C2 and the C2 system that supports that process.

The C2 process is characterized by the establishment of an organizational structure for decision makers and by a reduction of uncertainty sufficient to permit Commanders to make assessments and operational decisions. Although the reduction of uncertainty is an objective of much of the C2 process, the utility of uncertainty reduction is limited due to the two-sided nature of conflict. Conflict outcomes depend on decisions made by many Commanders on both sides. The C2 process relies on the shared understanding of separated Commanders, an understanding that itself relies on doctrine, teamwork, and previous information exchanges.

Commanders are clearly an integral part of the C2 process and should be seen as part of the supporting systems as well. While looking to improve the C2 system, one must remain focused on the needs of the Commander.

- A Commander must optimize control to the extent required to maximize mission performance. Commanders will be disinclined to delegate authority until they realize that failure to delegate will compromise the mission. Command is defined by balancing the risks associated with delegating authority against the risk of mission failure.

- Commanders can be given all available situational information, but this is useless unless they also know why a force acts the way it does. With knowledge of the enemy's intentions, Commanders can create strategy and plan and rehearse missions based on an understanding of bow the enemy thinks.

- The greater the political impact of mistakes, the more stringent the ROE and the more centralized the engagement authority. It is important that the C2 support system adapt to both highly centralized and decentralized engagement authority and provide the execution authority the correct level of situational awareness to enhance decision making. This will free the Commander from the task of organizing and fusing information, allowing the focus to be on decision rather than observation and orientation.

- Technology enables simultaneous C2 decision making, which provides the warfighter with faster, better, and more direct access to needed information. C2 technology must allow a Commander to step through the OODA loop faster than an enemy steps through his.

1.4 Unique Employment of Aerospace Power

1.4.1 Aerospace Power and Spectrums of Conflict. Aerospace power can move rapidly and with great agility uninhibited by geographic and environmental constraints. This ability, enabled by the appropriate C2 system, allows the Commander to attack targets across the spectrum of conflict-from the near tactical to the deep strategic-very rapidly and precisely. The challenge is to provide a robust C2 system which underwrites the Joint Force Air Component Commander's (JFACC) ability to fully exploit aerospace power in a joint warfighting scenario.

- The Air Force's need to operate across a broad spectrum of conflict to meet its theater-ranging responsibilities imposes a set of characteristics on its C2 system that are not required for those forces whose area of responsibility (AOR) is less than theater-wide.

- Across the spectrum of conflict, the threat, target set, and ROE are not likely to be uniform, requiring the Commander to make decisions and judgments concerning each engagement. A JFACC must be able to influence every sensor to shooter relationship.

These situations develop for many reasons and also include those forces that may be highly mobile and disadvantaged from a C2 perspective. However, these arc the stressing cases and must therefore influence the design of future Air Force C2 systems

1.42 Aerospace Power and Theater-Ranging Perspective. The Joint warfighting construct envisions a Joint Task Force (JTF) Commander who exercises overall command of the components present in the AOR. The JTF Commander has overall mission responsibility and authority.

- One of the first decisions the JTF Commander makes is the parsing of mission responsibility among Components based on the unique capabilities of each element. The Components then carry out the combat activities. This is the first step in the delegation of authority chain that eventually leads to action at the shooter level.

- Joint warfighting C2 systems must meet the needs of both the Joint and Component Commanders. The distinct nature of the Components (medium of operations, operations tempo, target and threat focus) will lead to specialized C2 requirements for optimum employment of each Component. To help explain this, envision a scenario involving a corps conducting ground operations, maritime operations in the littoral region, and air and space operations.

  ⇒ A C2 system designed to support operations in a 200 km square area is sufficient for a ground corps and a naval group, but not for air and space operations.

  ⇒ Air and space operations must correspond to the scope of the Air Component's mission and theater-ranging responsibility. The extent of the C2 system in this case is more vast than ground and maritime C2 systems.

  ⇒ The air and space C2 system must also support out-of-theater operations such as inter- and intra-theater transport and long-range bomber missions, which are likely to originate and end outside of the AOR.

  ⇒ The air and space C2 system must also accommodate and be interoperable with the other Components since the air and space elements will operate with, and around, the other forces.

  ⇒ The JFACC's C2 must be sufficiently agile and comprehensive to permit the JFACC to exercise command discriminately.

1.4.3 Aerospace Power Achieving Global and Theater Objectives with Speed and Flexibility. As stated above, the Air Commander must maintain awareness both globally and within the theater of operations. Working toward successfully meeting the Air Campaign objectives, the Air Commander must simultaneously concentrate on strategic and theater mobility; interdiction using assets from within the theater and outside the theater; ground maneuver combined with close air support; space-based operations; littoral maneuver and/or defense and theater air defense. Effective and timely application of the Air Force's inherent attributes of range, speed, flexibility, and long-range precision weaponry against a global array of potential adversaries having both modem weapons and information capabilities will depend on the effectiveness of its C2 resources. Unique aerospace attributes can be summarized as follows:

- air and space forces encircle the globe seamlessly and offer less resistance to movement than other mediums,

- aircraft and spacecraft can be moved very rapidly anywhere in the world,

- air and space offer unique vantage points from which to observe worldwide activities and, if necessary, engage targets,
- advanced technologies enable the employment of air-delivered weapons with greater lethality and precision.

1.4.4 Aerospace Power and C2—A Strategy-to-Task Relationship. The demands placed on Air Force C2 to effectively employ aerospace power derive from an end-to-end strategy-to-task examination. This review results in specific C2 tasks required during different phases of an operation. These phases include readiness, deployment, employment, sustainment, and reconstitution. The associated tasks and what C2 requires to meet those tasks are detailed in Appendix A. The tasks were derived from the following operational objectives:

- provide global reach and global power; i.e., deploy on short notice, fight with lethality on arrival, achieve and maintain aerospace superiority, project power from CONUS, and sustain operations,
- exploit agility, situation awareness, and technological superiority,
- rapidly assemble forces needed for a decisive win,
- terminate conflicts swiftly, decisively, and with minimum loss of life.

1.5 21st Century Changes and Air Force C2

The global political and economic factors coupled with US domestic factors have created a set of conditions which will have significant impact on Air Force global operations and the C2 systems that enable them. These factors demand a C2 system that can support operations effectively in constrained environments across a spectrum of conflict in many geographical areas, sometimes simultaneously. Some of these factors and conditions are summarized below.

- The shrinking DoD budget and changes in US military strategy are resulting in a largely CONUS-based force. At the same time though, the sphere of US interests continues to expand.
- Joint and coalition operations will be the norm, not the exception.
- Many operations may be simultaneous and widely dispersed geographically. In these situations, interoperability will be essential, particularly C2 interoperability.
- Regional access to facilities and communications may not be easy or at least as extensive as that available in CONUS. The infrastructure available to support operations may be limited. This is further complicated by the need for smaller forward deployments. The C2 system must be modular to enable tailoring for specific use with a minimum logistics footprint.
- The ability to understand what is occurring in the battlespace has made the Air Force aware of C2-imposed limitations on combat effectiveness. As a consequence, the true potential of aerospace power has not been completely realized.
- Aerospace power will be called upon to rapidly move military equipment, people, and supplies worldwide. Missions will range from isolating the battlefield in one part of the world and providing information to forces in another. At the same time, aerospace power must be prepared to fight an MRC anywhere in the world.

- Aerospace power will be the option of choice for many dimensions of conflict.
- The development and procurement of an agile, affordable C2 system to support future operations depends on the Air Force's ability to easily and routinely incorporate commercial technology. The current Air Force requirements and acquisition process is not fast or flexible enough to permit tbis routinely-change is needed.

These conditions have made the inefficiencies and cost of the current C2 systems intolerable; in fact, aerospace power is seriously handicapped by today's C2 system. The power of precision weapon delivery and target attack, and the ability to respond rapidly to and in any contingency are all inhibited to varying degrees today. Aerospace C2 for the 21st Century must be designed to remove these shackles in order to unleash the total capability that aerospace power possesses.

1.6 C2 Issues-Current Limitations

The current C2 system has a large mobility footprint and requires significant airlift and time to deploy. The equipment is labor intensive and inefficient, resulting in a larger number of people to operate and maintain it, at a time when personnel cuts are needed to reduce cost. The C2 system is inefficient at a time when there is no surplus of forces and inefficiencies are not only costly, but dangerous. Each C2 system that is deployed must be built from scratch and is ad hoc. In an era when becoming operational quickly is the norm, the time needed to build up these unique systems is a detriment.

Release of US information and planning systems to coalition partners is also done in an ad hoc manner. These procedures affect C2, and force application should be thought out ahead of time, to the extent possible, to ensure the most effective use of forces without delay. Interoperability must be planned for, and C2 systems need to be scaleable to enable the movement of the correct amount of C2 resources forward to meet the need. This includes having the capability to leave the preponderance of the C2 system out of theater with robust reach-back capability for adequate transmission and reception of information.

The C2 system must be able to support forces that may be highly mobile, may have little access to information, and with whom the US may have limited interoperability. The challenge lies in developing a C2 system that meets Air Force needs and at the same time facilitates interopcrability. This system must not only be robust to meet the wide range of challenges, it must also be robust against, and protected from, outside threats. These threats are not only physical but electronic as well, and the command infrastructure must be multi-dimensional (e.g., media, coalition, joint) and interoperable to the greatest extent possible.

The Air Force's ability to acquire data has out-paced its ability to integrate, fuse, disseminate, and use the information. Without adequate and accurate information, proper decisions cannot be made in a timely manner or at all. There is no common picture of the battlespace at the JTF and Component levels which can lead to inefficiencies at best and lost opportunities and increased fratricide at worst.

CONUS-based forces require the rapid global mobility that airlift can provide. Currently, combat and mobility C2 systems are not linked and are not agile enough to support the most lethal application of precision weapons of all kinds or to respond to the rapid changes that can occur on the modem battlefield. The current C2 system is a collection of independent systems often with incompatible data formats. Not only does this limit effectiveness, it severely inhibits interoperability and can cause unnecessary reattacks on missed targets.

Today's C2 systems am acquired as independent systems. These systems are usually stovepiped, which limits intra- and interoperability. C2 often becomes theater and/or mission specific, which increases training requirements, complexity, and support cost. There is little capability provided through modeling, simulation, and testing to demonstrate the value of new technologies. The current requirements, acquisition, and financing processes are not capable of keeping up with the rate of technology change and availability.

1.7 Commander's Operational Needs Enabled by C2

In the previous sections, the changes on the future military environment, limitations of the current C2 system, and the potential broad dimensions of aerospace power were discussed. All of these factors lead to the following key operational elements of the 21st Century.

- Battlefield knowledge based on common data sources, fused presentations, and decision aids.
- Scaleable, interoperable, tailorable systems with selective releasable products employing current technology.
- An acquisition process with sufficient speed to leverage and insert new and evolving technology.
- A C2 system that is measurable for value added using robust modeling and simulation, exercises, and real-world operations.
- Training, employment, and fielding issues addressed early in the acquisition process.

1.8 C2 Operational Concepts

Establishing a Vision of C2 for the 21st Century will require the development of a migration strategy to achieve that Vision and process improvements to implement that strategy. The migration strategies and process improvements must focus on enabling the following operational concepts.

- Leaner Equipment. The C2 equipment must be lighter, smaller, and more capable. Forward area computers should use flat screen technology or laptops to reduce the mobility footprint and voice recognition to avoid the need for keyboard and mouse. Voice recognition must also have language/dialect translation to allow for easy access and understanding by coalition partners.
- ommon Command Centers. Them will still be separate operations centers for Component level operations and unit level operations.
  - ⇒ Many component-level operations could be controlled from outside the theater of operations (eventually from CONUS). Many exercises have been conducted utilizing a robust communications infrastructure that have demonstrated distributed C2.
  - ⇒ Coalition operations will require US forces to operate within the theater as forward elements, and these elements will have force size constraints. Consequently, these forward elements must be lean in personnel and equipment, The Bosnia operation may not have been able to have been conducted from CONUS, but it could have been prosecuted from SHAPE in Belgium with the proper technology and robust over-the-horizon (OTH) communications.

⇒ Technology advances could allow the JTF Commander to maintain a rear area AOC that does not move in a conflict. The forward element would be used for dynamic execution only and involve no planning, intelligence analysis, or logistics elements. Plans would be established as priorities, objectives, and tasks materialize. Execution would be continuous. Fewer missions would be preplanned, and more missions would be established for dynamic operations executed from the m-theater execution authority.

- Multi-Functional Control Centers. Control centers should be multi-functional and tailorable to the conflict. Ground control centers should receive all information from the dispersed sensors, including ground, air, and space. C2 operations should be from the ground in the rear area utilizing OTH communications to interact with the shooters.

- Consistent View of the Battlespace. The Commander's situational awareness is an undefinable attribute, as it will depend on human personal traits and experiences. The C2 system must provide and make available to all Commanders a "recognizable picture of the battlespace." The system must include space, air, surface (land and sea) and subsurface and must contain blue, gray, and red force information. This information must be fused to avoid duplication and resulting confusion. The system must display ma-time information and be updatable within seconds or minutes, not days. Additionally, the system must be able to push or have operators pull information as necessary. All Commanders must have the option of having the same view of the battlespace to make knowledge-based decisions on courses of action.

- Distributed Operations. Future military operations will requite distributed collaborative planning and operations. The Ah Force must cooperatively schedule and problem solve using computer-aided tools. The C2 system must be tailorable to each decision making level from the JTF to the shooter. To reduce training and aid the speed of deployments, the systems must be "plug and play" capable. Analytical tools and algorithms promoting accelerated decision making will be required and OTH communications to all air and space platforms will be necessary to allow for execution of the long-range missions unique to the Air Force.

- Information Dominance. Information dominance is critical to the future warfighter. Information security must be incorporated in C2 systems and not be an "add-on" feature. The development of high bandwidth fiber optics and satellite communications, small high-performance computers, and sophisticated airborne and space based sensors offers the opportunity to m-evaluate C2 functions. C2 concepts have often been driven by a lack of information and the inability to move what little information was available.

  Today, new technologies offer the potential for comparatively unlimited information and the means to get that information wherever it is needed. Today's challenge is to realize that potential by adopting a disciplined approach to moving and fusing information and to make the information available at the right place and time. With this capability comes the need to accomplish Information Superiority, just as the Air Force pursues Air and Space Superiority. The information medium must be controlled; otherwise, future commanders will not have the necessary confidence to rely upon it.

1.9 Conclusion

The Air Force must develop and evolve its C2 systems to allow the fundamental capabilities embodied in Aerospace Power to be realized in the conduct of future mission in support of the JTF Commander's needs. These systems must have the following attributes and capabilities.

- Enhanced decision making tools which enable the decision maker to solve multi-dimensional time sensitive problems,

- Increased efficiency by allowing the operator to accomplish the task better, quicker, and with fewer mistakes by:
  - ⇒ providing information to the decision maker sooner,
  - ⇒ allowing Commanders to operate from the same knowledge base for common understanding of the battlespace situation,
  - ⇒ making information available, through integration, interoperability, and tailorable releaseability, to all operators for improved mission success,
  - ⇒ allowing flexibility to employ Aerospace Power across varying conflicts and differing levels of delegated authority,
  - ⇒ tailoring the information for mission and resource needs (rapid deployability enables split base operations),
  - ⇒ allowing the use of existing commercial infrastructures, where logical and reliable,
  - ⇒ allowing "plug and play" capability for quick and effective response to any operation,
  - ⇒ allowing for decisions based on a mission to task relationship, not a technology relationship.

With these new capabilities, the Air Force will be in a position to develop C2 concepts almost unconstrained by technology. For if the technology is not here today, the rapid pace of technological advancement almost guarantees it will be here tomorrow. The establishment of the C2 Vision is an attempt to bring together complementing services to aid the decision maker. All contain a major piece of the Commanders' necessary knowledge base, and without combining them, the information will be fragmented and unintelligible.

In the following chapters, the discussion will assess the current status of Aerospace C2, establish the 21st Century Vision for C2, and define the migration strategy and process improvements needed to attain that Vision,

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Chapter 2

Current Command and Control

2.1 Introduction

In this chapter, the fundamental tenets of Command and Control, the methodology used within the command decision process, and the specifics of the C2 structure used by aerospace systems will be established. The aerospace mission tasks for defensive counter air (DCA), close air support (CAS), and interdiction (INT) during the three phases of conflict-planning, execution, and sustainment-will be defined. The process, along with a detailed assessment of command structures, sensor systems and their connectivities, and air platforms (shooters) and their connectivities (see Appendix B), was used to define a set of future goals and improvements for current aerospace C2 systems.

2.2 Essence of Command

Commanders must "command" and "control" air and space assets to accomplish missions. Command is where mission responsibility and authority reside. This includes the authority and responsibility for effectively using available resources and for planning the employment of organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. Control enables command, transforming the Commander's intent into actions. Control is dependent on the Commander's ability to insure forces have sufficient situational awareness of the battlespace to include disposition, movement, and intent of red and blue forces. As forces become involved in operations other than war, information on forces not directly engaged in the conflict comes into play as well.

Command responsibility cannot be delegated but authority can and must be delegated to execute missions. Command depends on communications to insure direction from higher headquarters reaches the proper subordinate command. Key to effective control of forces is the successful communication of delegated authority to act on assigned missions to the appropriate unit level. The greater the political impact of an engagement mistake, the more stringent the Rules of Engagement (ROE) and the more centralized the Commander will hold engagement authority.

2.3 Historical Perspective

The history of command can be understood in terms of a race between the demand for information and the ability of command systems to meet that demand. The Commander that effectively observes, orients, decides, and acts the fastest will achieve the greatest success. Concepts of command and control, as technology progressed with the introduction of the first radios followed by radar, computers, and satellites, have changed to take advantage of each generation of new technology. As a result, command and control concepts are often held hostage by technology's ability to provide situational awareness essential to command and the communications essential for control. Communication enables or constrains the control of forces. Some examples are summarized below.

- The tactic of a World War I fighter pilot in single combat with the enemy arose, not because anyone thought it was the best way to use airpower, but because once an aircraft was launched there was limited ability to communicate with it. This "fire and forget" version of command and control was driven by the technology of the times.

- Long-range high frequency (HF) radio and telephone technology in World War II was the key to making "centralized control and decentralized execution" a realizable concept. Both situational awareness and control were maintained by voice radio and low speed teletype traffic. Using this technology, the Allies could mass widely dispersed air assets at critical points and times.

- The establishment of an Airborne Battlefield Command and Control Center (ABCCC) in Vietnam did not reflect US judgment that the function of command and control was best accomplished from an aircraft; rather, it reflected the technology of the times. The available line-of-sight radios limited the radius that ground-based command centers could control combat aircraft.

- Desert Storm was a sensor and shooter rich environment which utilized many advances in technology. This environment highlighted several limitations to combat effectiveness that previously escaped notice; i.e., limited ability to put sensor and shooter together to handle the Transporter/Erector/Launcher (TEL) problem. Desert Storm provided a so-called "technology battle laboratory" for command and control systems.

The point of these examples is not that the command and control concepts were right or wrong. They were merely the best that could be developed using the available technology. In each case, the command and control system was constrained by the current technology's ability to provide situational awareness to the Commander and to transmit orders from the Commander to the forces. While the technology of command and control of fighting forces has evolved over the history of warfare, the basic concepts of command and control have not.

2.4 Commander's Decision Making Method-OODA Process Model

Commanders use a process for logical decision making while conducting the planning, execution, and sustainment phases of operations. There are many different processes that can be used to categorize the decision making steps. The important issue is that some process must be used to ensure the best decisions are made. This report will utilize the OODA process model—Observe, Orient, Decide, and Act-to address the command and control issues associated with a Commander's decision process.

When an individual (commander or shooter) needs to make a decision, he must first observe what is happening in his area of responsibility. Next he orients himself to what the observation means. Then he decides what to do about the observation. And finally, he takes action himself or by direction of others.

The OODA process describes decision implementation within the battlespace. Sensors can be directed to observe the battlespace reality. Processors, displays, and analysts supply decision makers with the means to visualize and orient themselves in the battlespace. This knowledge of the battlespace leads to the Commander's course of action. Following the course of action decision are the command and control action and task execution. The execution act for command and control involves communicating the authorization to act to military forces.

The OODA process is used by Commanders during the planning, execution, and sustainment phases of a broad spectrum of operations while conducting any of the many missions the Air Force is tasked to accomplish. Some of these missions include defensive counter air, offensive counter air, close air support, interdiction, strategic attack, and airlift.

2.5 Current Air Force Command and Control

As part of this review of the current Air Force command and control structure, it is understood that there are joint and coalition forces that join and complement the Air Force C2 structure providing sensor inputs, control centers, and command centers. The discussion that follows is intended to focus only on the Air Force portion of this joint environment.

Interoperability is key to joint and coalition operations, and as communications are enhanced within the Air Force structure, this enhancement must be applied to the joint and coalition environment as well.

2.5.1 **Terms.** Prior to discussing the current Air Force C2 structure, it is important to understand several elements that relate to C2 systems in general.

- Command Center. A command center is a facility from which a commander and his or her representative directs operations and controls forces. It is organized to gather, process, analyze, display, and disseminate planning and operational information and perform other related tasks. The Air Operations Center (AOC) is the senior element of the Air Force Component Commander (AFCC) from which command and control of air operations arc coordinated with other components and services, It is the principal air operations installation from which aircraft and air warning functions of combat air operations arc directed, controlled, and executed. The AOC is supported by Control Centers.

- Control Center. Control Centers extend the AFCC's control into the forward battlespace. These Centers facilitate execution of mission directives in accordance with the rules of engagement and airspace control and can direct action if authority has been delegated to them. Control Centers include the Control and Reporting Center (CRC), the Control and Reporting Element (CRE), Airborne Warning and Control System (AWACS), ABCCC, the Air Support Operations Center (ASOC), and on some occasions the Joint Surveillance, Targeting and Attack Radar System (JSTARS).

- Subordinate Oocrations Center. Subordinate operations centers are facilities from which unit commanders and their representatives direct operations and control assigned assets. They are responsible for planning, executing, and sustaining forces to meet the AFCC's air campaign objectives. These include the Wing Operations Center (WOC) and the Squadron Operations Center (SOC).

- Sensors. Sensors are tasked to detect, collect, and distribute data obtained from the battlespace. This data includes electronic intelligence, communications intelligence, human intelligence, imagery, raw radar data, and electro-optical data. Sensors include JSTARS, U-2, Rivet Joint, and National assets. Sensor data also includes that from AWACS and the CRC and CRE (TPS-75) radars, plus fighter and bomber radars.

2.5.2 Missions. The elements described above come together to accomplish mission tasks. The following three mission examples arc provided to demonstrate general relationships between the above identified elements while conducting mission tasks.

- Defensive Counter Air. The objective of the DCA mission is to control the air by directing, identifying, interrupting, and destroying enemy aerospace forces attempting to attack friendly forces or to penetrate the aerospace environment above friendly forces. Command and control for DCA starts with the JTF establishing the general guidelines, weight of effort, and ROE. The JFACC, using the AOC, specifically identifies the available resources using inputs from the WOC, the area to be covered, airspace restrictions, controlling agencies, and support (refueling, additional sensor coverage), among other issues. The AOC publishes the mission plans in the Air Tasking Order (ATO) and the airspace plans in the Airspace Control Order (ACO).

  During mission execution, the AOC can observe the DCA missions as they unfold from a large screen display showing air tracks received and passed from the control centers. Control of the shooters is normally delegated to the control centers, specifically AWACS, CRC, and CREs. These control centers are responsible for establishing the orbit points for the lighters, deconfliction (friend from foe, and airspace), threat warning, target assignment, maintaining status of fuel and munitions, refueling as necessary, establishing a fighter flow to ensure complete area coverage, and updating weather and return base status.

During the operation, sensors are detecting and collecting data. Information from Rivet Joint is passed to the ground AOC and to AWACS, while information from U-2 and National assets is passed to ground stations and eventually to the AOC. The main sensor for the DCA mission is onboard the AWACS, and organic to the CRC and CREs (TPS-75). If both AWACS and the CRC are participating, the CRC will be designated as network control and will receive information processed from the AWACS, correlate with information from the CRC and CRE, and pass one air picture to the AOC. The AOC receives threat warning information fused from intelligence sources. If the AOC passes threat warning information directly to the shooters, it is done via voice and requires beyond line of sight communications (radio relay).

The AOC usually delegates this warning responsibility to AWACS, CRC, and CRE. As a threat is inbound, the control centers direct the fighters to pursue the target in accordance with the ROE. For example, in hostile ROE, where targets falling within a defined profile are declared Hostile, the fighters will be directed to kill the target. But during peacetime ROE, where the fighters can only defend themselves if fired upon, a visual identification is usually required. In this situation, the authority to shoot has not been delegated to the control center or the shooter but retained by higher authority.

· Close Air Support. CAS is "air action by fixed- and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the tire and movement of those forces." Just like DCA, command and control for CAS starts with the JTF Commander establishing the general guidelines, weight of effort, and ROE. The AFCC, using the AOC, specifically identifies the available resources using inputs from the agencies, and support requirements (refueling, additional sensor coverage). The AOC publishes the mission plans in the AT0 and the airspace plans in the ACO.

During mission execution, the AOC can observe the CAS missions as they unfold from a large screen display showing air tracks received and passed from AWACS and other sensors. Control of the shooters is normally delegated to the ASOC, who further delegates specific control to the Forward Air Controller (Airborne) [FAC(A)] or the Tactical Air Control Party (TACP) aligned with and working in close proximity to the ground forces. A terminal attack controller (TAC) within the TACP, coordinates with the ground commander of the supported forces for final clearance. The final clearance or "cleared hot" is then relayed to the FAC(A) or if no FAC(A) is available, directly to the attacking fighters. Situations not involving a TACP or strikes which do not pose a threat to friendly forces may not require a final clearance call from the ground commander. In such situations the FAC(A) acts as the final controlling agency for the fighters. The ABCCC is also used as an airborne ASOC and radio relay for the shooters. The controllers [FAC(A) or TAC] are responsible for establishing the orbit points for the shooters; deconflicting airspace; passing threat warning; updating weather, target assignment, and return base status; maintaining status of fuel and munitions on each shooter; and establishing a shooter flow to ensure shooters are rotated for timely area coverage. The main role for augmenting control centers (AWACS, JSTARS, CRC, and CRE) is to provide supporting information to the ABCCC, ASOC, FAC(A) and TACP (if in communications range) to include area wide surveillance for threat warning, weather updates, refueling support if required, return base status, and any other required support. AWACS, CRC, and CREs will usually control the shooters to a contact point where the fighters establish communications with the final controller, FAC(A) or TACP. After exiting the actual mission area, the fighters again contact AWACS, CRC, or CRE for routing instructions. The main sensors for the CAS mission are the eyes of the airborne FAC and the ground TAC, and threat information from AWACS, CRC and CRE's radar.

- Interdiction. The objective of the interdiction mission is to delay, disrupt, divert, or destroy an enemy's military potential before it can be brought to bear against friendly forces. As with all missions, the command and control for INT starts with the JTF establishing the general guidelines, weight of effort, and ROE. The AFCC, using the AOC, specifically identifies the available resources using input from the WOC, including the area to be covered, airspace restrictions, controlling agencies, and support (refueling, additional sensor coverage). The AOC publishes the mission plans in the AT0 and the airspace plans in the ACO.

  During mission execution, the AOC can observe the INT missions as they unfold from a large screen display showing air tracks received and passed from the control centers. Ground tracks are displayed on a separate screen as input from JSTARS. The main role for augmenting control centers (ABCCC, AWACS, CRC, and CRE) is to provide supporting information to the shooters to include area wide surveillance for threat warning, weather updates, refueling support if required, return base status, and any other support required. AWACS, CRC, and CREs will usually control the shooters ingressing to target initial points or when returning from a completed mission.

  During the operation, sensors are detecting and collecting data. Information from Rivet Joint is passed to the ground (AOC) and to AWACS, while information from JSTARS, U-2, and National assets is passed to ground stations and eventually to the AOC. The AOC receives threat warning information fused from intelligence sources. If the AOC passes threat warning information directly to the shooters, it is done via voice and requires beyond line of sight communications (radio relay) using ABCCC, JSTARS, or AWACS. The AOC must also use this same radio relay method to m-task, m-target, abort, or make any changes to the ATO-tasked missions once the shooters are airborne and are ingrcssing beyond line of sight to the target.

2.5.3 Three **Phases.** This report will address three phases of operations-planning, execution, and sustainment-which must occur in order to execute any mission. The tasks that must be done during each phase arc associated under the OODA process model. For example, to plan an operation the planner observes the battlespace to know what is available, orients on the data to determine what can be used for the plan, decides what to do, and then builds and disseminates the plan. The other two phases (execution and sustainment) follow the similar tasks under the OODA process.

- Phase I-Planning. During this phase, the JFACC is planning for air battle execution in accordance with the Joint Force Commander's campaign plan objectives,

  ⇒ **Observe** the battlespace to support plan development.

  Tasks: Detect and Update.

  Current Method: The AOC has no organic detection sensors. All detection is done externally and provided to the AOC. The AOC receives automated inputs via digital communications for the Red Force Order of Battle (OB), but manual inputs for the Blue Force OB. Both Red and Blue air arc provided automatically via digital communications to the AOC. Updates for Red Force OB are automatic in the data base, but the Blue Force data base is incomplete, covering only air OB (aircraft, bases, weather and munitions). Sensors (JSTARS, U-2, Rivet Joint, and National assets) provide threat detection directly to some control centers. AWACS, CRC, and CRE have their own organic sensors to detect air movement and update data bases via automated means. Neither the ASOC nor the ABCCC detect movement directly. JSTARS detects ground movement and provides this data via digital communications to the AOC. The remaining sensors provide various intelligence data via digital communications to the AOC. The WOC detection is data base related in the tracking of status of resources. Internal to the WOC, this process is automated but not outside the wing or across wings.

⇒ Orient to prepare to support plan development.

Tasks: Identify, classify, correlate, and fuse.

Current Method: The AOC receives identification, classification, correlation, and fusion from external sources. This process is automated via digital communications. AWACS, CRC, and CRE identify and classify air tracks via direct computer interface and pass this information to the AOC via digital communications. JSTARS identifies and classifies ground tracks and passes this via digital communications to the AOC. Correlation of air tracks is normally done by the CRC, coordinating data passed from AWACS, Patriot Surface to Air Missile units, and CRE. A level of fusion occurs between AWACS and Rivet Joint, and this is passed down to the CRC. There is also fusion that occurs on some Red Force assets from National assets, U-2, and Rivet Joint to the AOC mainly on the Red Force OB information. In the WOC, this task relates to tracking of status of resources. Internal to the WOC, this process is automated but not outside the wing. This information is passed to the AOC via fax, email, or message.

⇒ Decide the objectives and rules.

Tasks: Collect observations and apply to JTF and JFACC objectives. Determine course of action, establish rules of engagement and levels of authority.

Current Method: This process is manual today,

⇒ **Act** to build the plan.

Tasks: Develop the master attack plan. Assign assets, timing, weapons, airspace. Develop the ACO and the AT0 or Air Tasking Message (ATM) within the constraints of the ROE. Publish and distribute the ATO/ATM and ACO and ensure receipt.

Current Method: The development of the master attack plan (or the battle flow for the next 24 hour period) is manual, done with greaseboard or possibly spreadsheet computer tools. The assigning of assets, timing, weapons, and airspace is automated. The development of the ACO and ATO/ATM is automated. The development of the ROE is manual, usually accomplished by cutting and pasting from a word processing document. Publication and distribution of the ATO/ATM and ACO are automated via digital communications, email, and fax depending on the communications connectivity. The ATO/ACO from the AOC is passed via digital communications to ground control centers, but not airborne centers. At the control centers, the process of assigning assets, timing, weapons (i.e., air defense artillery) airspace, and requesting changes is manual. At the WOC, there is no direct system to system link between the AOC planning system and the wing planning system. The mission planning process is automated at the WOC, but the information must be manually inserted.

- Phase 2—Executing. During this phase, the air plan, in accordance with the air campaign objectives, is executed.

  ⇒ **Observe** the battlespace to support mission execution.

  Tasks: Detect and update.

  Current Method: The tasks of detect and update within the Command and Control process are unchanged between planning and execution with the exception of pilot reports via voice about the fluid battlespace.

  ⇒ **Orient** to support mission execution.

  Tasks: Identify, classify, correlate, fuse.

  Current Method: The tasks of identify, classify, correlate, and fuse within the Command and Control process are unchanged between planning and execution.

  ⇒ **Decide** course of action and make, or recommend, adjustments as necessary.

  Tasks: Collect observations and apply to JTF and JFACC objectives. Evaluate course of action for mission success. Make or request changes as necessary.

  Current Method: This process is manual today.

  ⇒ **Act** to execute assigned missions.

  Tasks: Execute the assigned missions (DCA, CAS, INT, OCA, Strategic Attack, Airlift, etc.) as planned. Provide threat warning, target updates, and weather updates for these missions. Request sensor support, re-task assets and sensors, conduct re-targeting, abort missions as required, and report results to JTF.

  Current Method: The AOC can observe the air battle as it unfolds from a large screen display showing air tracks received and passed from the control centers (AWACS, CRC, etc.). Ground tracks are displayed on a separate monitor if the downlink is available from JSTARS. This usually only covers the DCA and CAS missions, some Airlift, and the initial stages of the INT, OCA, and Strategic Attack missions. The AOC is unable to observe and communicate with the beyond line of sight strike missions without a sensor or communications relay.

  The AOC monitors AT0 execution (take-offs, landings, and aborts) today manually, mainly by voice. Once information is received, the AOC data base can be updated by the AOC operator. The AOC usually delegates threat warning responsibility to the control centers (AWACS, CRC, CRE, ABCCC). The AOC receives threat warning information fused from intelligence sources. If the AOC passes threat warning information directly to the shooters, it is done via voice and requires beyond line of sight communications (radio relay). Target updates can be passed from the AOC via digital communications to the flying units before take-off, but after take-off must be done via voice using the controlling centers as radio relays [AWACS, ABCCC, CRC, FAC(A), etc.]. The AOC uses voice to request or re-task sensors, re-task assets, re-target, and abort missions. When beyond line of sight, the AOC uses radio relays (ABCCC, AWACS, CRC, CRE, Tankers, FAC, and other shooters) to pass this information.

Battle damage assessment is passed mainly via digital communications but can also be via voice. Report development is manual and forwarded, using digital communications, to the JTF. The control centers provide, to the shooter, threat warning, target assignments, target changes, target and weather updates, mission aborts, and sensor support requests via voice. The exception is between Link 16-equipped F-15s and **AWACS,** which allows target assignment via digital communications. The CRC can assign targets to air defense artillery via digital communications.

Mission results are passed via voice from the shooter to the control center and to the AOC. The WOC provides threat warning and weather updates to returning and/or inbound aircraft via voice. Additional mission support, if required, is requested via voice, email, and/or fax to the AOC. **Mission aborts are passed via voice, email, and/or fax to the AOC.** Battle damage assessment is passed electronically via digital communications to the AOC.

- Phase 3—Sustaining. During this phase, the objective is to sustain forces at the level required to meet the Commander's objectives.

⇒ **Observe** resources to sustain the battle.

Tasks: Detect and update.

Current Method: The AOC has no automated capability to detect the Blue Force OB. Updates to the AOC are received from assigned forces manually via voice, fax, and email. Once the information is received from the field, the AOC operator can update the data base, but only for aircraft, bases, weather, and munitions. At the control centers, this process is manual today. At the WOC, this process is automated within the wing but not outside the wing.

⇒ **Orient** on shortfalls and overages,

Tasks: Identify, classify, correlate, and fuse.

Current Method: The AOC manually compiles status reports from the units to identify, classify, correlate, and fuse shortfalls and coverages. There is an automated method to track aircraft and munitions, but this mcthod uses manual data insertion techniques. At the control centers, this process is manual today. Internal to the WOC, this process is automated but not outside the wing.

⇒ **Decide** the course of action.

Tasks: Collect observations and apply to JTF and JFACC objectives. Evaluate and assess course of action. Make changes as deemed necessary to continue current and projected operations tempo.

Current Method: This process is manual today,

⇒ **Act** as necessary to request additional support.

Tasks: Request more assets (aircraft, bombs and bullets, fuel, **people,** communications) or cancel assets as necessary. Request airlift for assets and/or personnel. Direct movement of assets within theater.

Current Method: The AOC requests more assets and cancels assets using automated means and over the horizon reachback digital communications to the rear area or CONUS. The AOC directs movement of assets from one area to another via email or message. The AOC requests additional airlift support via voice, fax, email, or message to the JTF (strategic lift) and via digital communications (theater lift). Today, this process is manual at the control centers and automated at the WOC.

2.6 Assessment of the Current Command and Control System

Appendix B contains examples of the methodology used to assess the current command and control system. During the course of the study, functional and systems architecture models were reviewed for the AOC, CRC, CRE, ABCCC, AWACS, ASOC, WOC, and JSTARS. An analysis was conducted on the flow of authority between C2 echelons during Bosnia, Desert Storm, Haiti, and Korea. An analysis was conducted on the tasks required during DCA, CAS, INT for mobile targets, and INT for fixed targets, Airlift, OCA, and Strategic Attack missions. Further assessments were conducted on the current relationships, tasks, and levels of authority between the C2 and sensors, and C2 and shooters during these missions. Finally, a review of the planning, execution, and sustainment phases of operations, overlaid on the OODA model, with the tasks defining how command and control functions was conducted.

During the analyses, the study panels assessed patterns associated with the specific command and control tasks in a variety of operations and authority relationships. These ranged from peacekeeping operations in Bosnia and Haiti on one hand to major regional conflicts on the other. These analyses demonstrated that the fundamental tasks required for C2 are essentially the same over the range of missions, variations in authority flow, and phases of conflict discussed earlier in this section. The Air Force understands how to execute Command and Control and to date has executed it effectively for all missions over all stages of conflict. This was demonstrated during operation Desert Storm and in Bosnia.

The conclusion is that the fundamental structure of C2 is not broken. However, the process of C2 could be made more efficient and effective over a broad set of missions by the application of information technologies which can extend the range of operation and reduce the latency from observation to execution. Range and speed of communications shortfalls exist for some missions, particularly those requiring long-range operations against time critical targets. When analyzed against missions, the panels found many C2 similarities between the tasks required when conducting DCA and INT against mobile targets. The C2 structure was designed to work in close proximity to forces (friend and foe) for DCA and CAS and was not designed to reach deep into enemy territory, particularly for time critical targets.

The Air Force's Core Competencies of Global Presence, Reach, and Power are outpacing its C2 systems. Today, the C2 system is piecemealed each time a conflict arises. Capabilities are strung together in order to give the Commander the best look available, and this is not the most efficient way to tight a war. When analyzing the OODA model, it is obvious that manual decision processes and line of sight communications are inadequate for effective mission execution.

Information technologies, properly applied, can increase C2 efficiency and effectiveness. The Commander's ability to observe, orient, decide, and act can be greatly enhanced if the future C2 systems can:

- provide theater-wide sensor data, fused together for a clearer understanding of the operational situation,
- provide this information to decision support tools to add center of gravity analysis covering strategic, operational, and tactical, including both friend and foe,

- provide modeling and simulation capability for execution analysis to "fly the missions ahead of time,"
- provide robust communications with over-the-horizon connectivity to extend operations and the Commander's control both into and out of the theater and into and out of the cockpit,
- be employed with fewer people, less time, and less support tail and airlift, facilitating rapid deployment and operations.

These goals will be used in Chapter 4 to establish a migration strategy that will lead to the Vision of Aerospace C2 developed in Chapter 3.

Chapter 3

Vision

3.1 Introduction

The Air Force has proven its ability to successfully conduct large scale air operations in support of a joint theater campaign, to carry out humanitarian airlift worldwide, and to meet special needs such as emergency evacuations of people in danger. Despite these successes, it is obvious that the ability of the US to command and control its increasingly scarce resources is not adequate for many present and future missions. For example, current C2 support systems have not kept pace with combat capabilities, and airlift operations suffer from a lack of connectivity and an inability to track cargo. As a result, an intensive effort to improve these C2 systems is necessary. By taking advantage of the opportunities technology can provide, the Air Force can significantly change its C2 process on a global basis. This chapter provides a vision of how an increased knowledge of the battlespace and a vastly enriched electronic integration of resources can leverage air component assets in projecting overwhelming land, sea, and air power,

The employment of such power is a necessary but certainly not sufficient capability to serve the future military needs of the US or its allies. There are some attributes of future hostilities that do not surrender well to overt power. Precision weapons directed at very specific targets are fine if their locations are known and they are not encumbered by untargetable cover. The enemies of the future will not always bare themselves as in Desert Storm but will more likely meld with their familiar background, including the innocent, to render the use of large scale power ineffective. That tendency does not remove the imperative for small precise weapons, either lethal or non-lethal. But opposing and defeating such tactics will demand much more accurate and timely knowledge than exists today. The most important asset to use such knowledge effectively is an integrated, responsive, and ubiquitous C2 system.

The C2 systems of the future, therefore, need to serve the more traditional functions of large scale MRC-like operations in which the enemy is identifiable and separable, but they must also serve those less defined and much more difficult types of conflict in which the enemy is not so obvious. All conflicts tilt victory toward those with preferential knowledge and the means to take advantage of that knowledge. It is the nature of the weapons used and the adaptability and speed with which they are employed that will spell the difference. Early, rapid, and continuous neutralization of enemy intent puts great reliance on the gathering and intelligent use of information. The information revolution emerging in industry will inevitably reach the battlespace.

As an aside, in this chapter there is little use of the acronyms normally associated with command support systems. The Vision is meant to deal with the command and control of aerospace power, and as much as possible, the use of the acronym jungle that has surrounded this topic since World War II has been limited. Tight command cycles may require greater functional integration, but there is also a need to discuss the individuality of command separate from the systems that support command. Command and its functions are often buried under a preference to discuss technology.

3.2 A Vision for Future Command Support Systems

Global command and control of aerospace forces throughout the spectrum of military operations by exploiting information to know, predict, and dominate the battlespace

The mission associated with ***executing this*** vision is to:

> ***Engage aerospace forces lo observe, shape, and affect the battlespace and to operate these forces in a joint or coalition environment as directed***

3.3 Characteristics and Attributes-C2 System of the Future

Given this vision and mission, what are the basic characteristics and attributes that future C2 systems need to have to effectively achieve global command and control? Much will be based on an ability to acquire and exploit information considerably better than is currently done. Future C2 systems should be able to:

- work across the full spectrum of military operations-anywhere, anytime,
- support all levels of joint and coalition command,
- gather and create information to enable global situation awareness,
- leverage use of accurate knowledge of enemy and friendly forces,
- enable employment of precision weapons,
- enable operations beyond the horizon,
- use publicly available information and accommodate high media visibility,
- afford low forward logistical footprints with rapid, automatic resupply,
- provide a consistent infrastructure, tailored to individual commanders and ***types of*** conflict,
- offer the flexibility and redundancy of virtual command centers, logically together but physically separated,
- facilitate the rapid and evolutionary incorporation of technology,
- provide secure virtual subnets for mission-specific, collaborative groups,
- provide a common logical database accessible to authorized users,
- enhance decisions via automated decision tools exploiting simulation and modeling techniques,
- enhance command through observation, knowledge, prediction, and ultimately dominance of the battlespace.

The above attributes are meant to characterize the C2 support system of the future. While the technologies exist to deliver essentially all of these attributes, bringing them into the operational settings of the DoD will take considerable time. Doing so is dominantly a process issue and requires that the engineering and acquisition segments of the various Services accept these attributes as requirements or guidelines for the new systems they choose to either build or buy. Chapter 5 suggests a process to allow the Air Force to develop and then enforce the reference standards that will be needed to assure the highest possible levels of internal and joint interoperability.

3.4 C2 **Systems of the Future**

Figure 3-l depicts the dimensions over which command and its support systems must function. It is an important aid in indicating the wide variability of tomorrow's conflicts. One can imagine a region or operating point in this space that characterizes any specific conflict. The use of this figure is to test the range of utility of any given C2 support system. It would be very desirable that any C2 system of the future be able to operate anywhere or everywhere in this space. Challenges to that universality will be the diverse needs of the various types and scales of warfare and the wide range of computing capacity found across the user dimension that are imposed by present and legacy systems. The ongoing rapid development of C2 supporting technologies, however, should work to provide compatibility across a communications and computing environment.

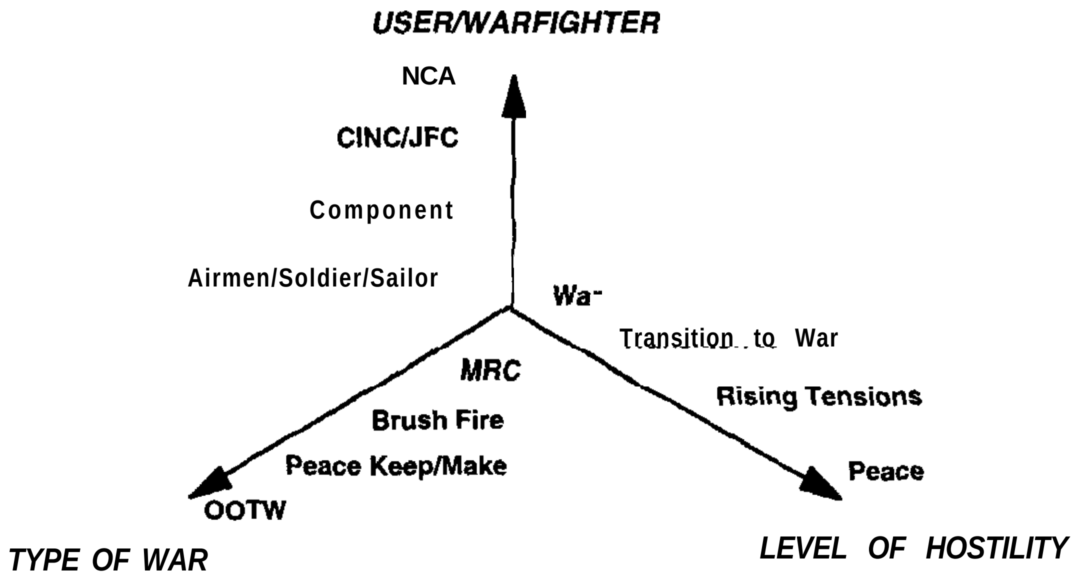


Figure 3-1. Dimensions of Military Operations
(Note: The C2 support system must operate at all points in this space)

Given these dimensions of conflict and a vision for C2 that relies on the global acquisition and use of information, the three basic parts of this discussion are:

- <u>global awareness</u>-worldwide awareness, situation knowledge, battlespace precision,
- <u>dynamic olannine and execution control</u>-timely and accurate planning, informed decisions, managed execution,
- <u>mat' over-the-horizon operations</u>—information collection, resource management, distributed operations.

Each of these areas is replete with detail that can't be addressed in this report. However, areas where the gathering and use of accurate information will provide good near-term advantage will be identified. In other cases, attention will be directed to where such information may be difficult to obtain.

3.4.1 The Operational Aspects of Global Awareness. The portion of the vision statement dealing with "...exploiting information to know, predict, and dominate the battlespace" is accomplished only through an ***ability*** to consistently "out-know" your enemy. Awareness is tine globally and connotes strong vigilance, but the closer to the focal point of battle, the more. complete the assessment and situation knowledge need to be. Critical mobile targets are a good illustration of the detail of information needed and the difficulty in responding to that need. Regrettably, a "shoot and cover" guerrilla-type of enemy may have great advantage over more overt forces in this regard, especially when the worldwide and omnipresent news media are an integral part of the friendly side.

The ability to precisely know and target an enemy more quickly than he can react will be a fundamental attribute for all future conflicts and thus C2 systems. From an operational viewpoint, global awareness requires that all information sources give near-real-time and near-perfect knowledge. The military requirements of individual missions may permit the system to trade timeliness against quality in particular instances. However, the awareness system's product must contain a greater array of information. Most importantly, the system must contain a ground picture that is similar in nature to the air picture now maintained for the CRC. This picture must be available for all relevant military operational areas, with quality (geo-location, resolution) sufficient to accomplish the task at hand.

The key is near-real-time, near-perfect knowledge. Near-real-time knowledge means timely enough to do something militarily significant such as to bring tire on a target while the target is still on an observable or predictable track. Near-perfect knowledge also means that you know enough to do something militarily significant. For example, the resolution of sensing systems and their corresponding geo-location accuracy must be at least as good as the precision of the weapons, both lethal and non-lethal.

Global awareness must also ensure that relevant military objects, both friendly and enemy, are quickly determined from real-time battlespace surveillance, rapid Battle Damage Assessment (BDA), and self-reporting of friendly forces and material. The objects include, but are not limited to:

- traditional fixed and mobile objects on land, air, sea, and space,
- C2 structures, communication links and nodes, and computer systems,
- people,
- mobility and logistic platforms, depots, and command centers.

Global awareness in this context is knowing the ***precise*** location, purposes, and readiness of all combat and support forces, blue, gray and red. In peacetime, the status of forces, transportation, and material is known. In wartime, a similar picture exists, but with tighter timelines and increased accuracy. For the logistical system, what to send, where to send it, and where it is in transit are all pieces of information that need to be known. The logistical support system should be highly automated, running as a background process that is able to sense the need for replacement and replenishment and to dispatch specifically what is needed for continuous sustainment.

3.42 The Operational Aspects of Dynamic Planning and Execution Control

A second major area of future C2 systems addresses the intelligent use of the relevant knowledge acquired in global awareness to plan and execute missions. Figure 3-2 presents the cyclical and linear planning of execution control systems in place today.

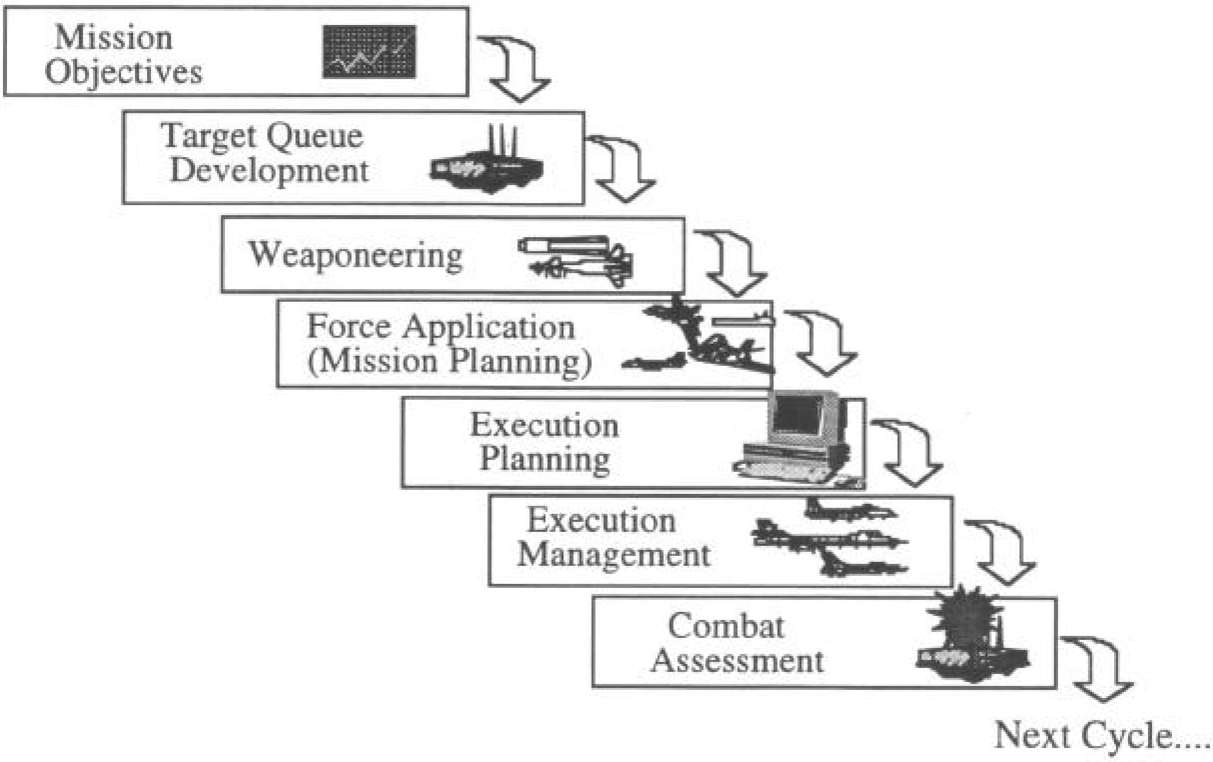


Figure 3-2. Current Cyclical Linear Planning System

The type of plans required in the future and the nature of constraints on the planning and execution cycle will be highly varied. Traditional, slower paced planning functions and methods will be difficult to leave behind. However, new planning systems must be designed that can operate in a nonlinear, asynchronous, and interactive manner.

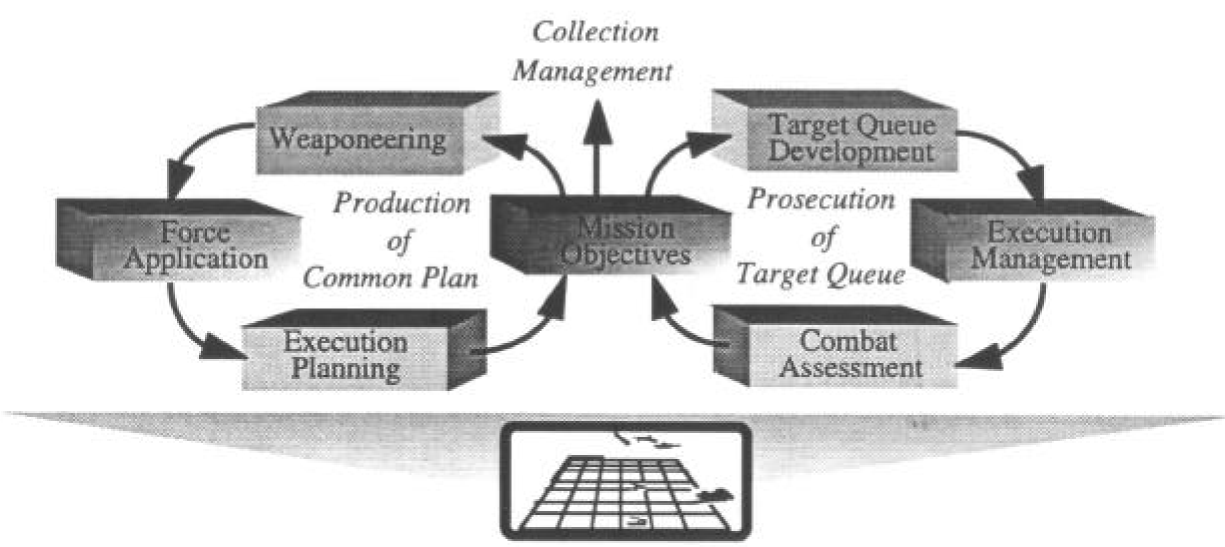


Figure 3-3. Future Nonlinear, Asynchronous Planning System Operation

Even during peacetime, operations must be real-time, continuous, and dynamic. This is necessary so that the speed needed in actual hostilities will not seem unnatural. Some of the major actions involved in dynamic planning involve:

- inserting appropriate military objects in the target queue using:
  - ⇒ JFACC campaign objectives and rules of engagement,
  - ⇒ land, maritime, SOF, and coalition inputs,
  - ⇒ weather,
  - ⇒ faster-than-real-time simulations for understanding the impact of decisions,
  - ⇒ prioritized within mission categories,
- mobility and logistics actions that are responsive and automatic such as:
  - ⇒ requirements that arc automatically determined during both planning and execution,
  - ⇒ staging and resupply actions that are initiated immediately and tracked by process runs in the background automatically.

The mobility and logistics pictures change as the target queue is prosecuted. Changes may be anticipated and actions taken in advance. Adaptive changes will be required, brought about by BDA or other factors during target queue prosecution.

As the target queue is dynamically built, it is also dynamically executed. The joint actions necessary to prosecute the target queue are to:

- match weapon systems and weapons to each target,
- select most efficient weapon systems matching weapons to target; mitigate collateral damage (these weapons range from air, space, land, and sea delivered munitions to information weapons),
- organize and dispatch the weapon (air, space, land, sea, information),
- attack in seconds, minutes, hours,
- execute in parallel rather than sequentially (ready, fire, aim),
- organize to prosecute the target queue using an Attack Controller (similar to the CRC) that can be located anywhere (air/land/sea, in or out of the theater of operations),
- execute authority determined by the rules of engagement (decentralized as in Desert Storm, or centralized as in Bosnia),
- continuously refresh the battlespace picture from sensor information to include red and gray force activity, BDA, and dynamic re-prioritization of targets.

The dynamic planning and execution cycle is a continuously repeating process of building the picture, developing the target queue, prosecuting the queue, and updating the picture.

3.4.3 Over-The-Horizon (OTH) Operations. The third area that the vision calls for is over-the-horizon operations. In particular, OTB operations should become routine and eliminate the current dependency on line-of-sight communications. Activities and conditions that will force reliance on OTB communications and connectivity are:

- remote information collection and sensor control for awareness and planning,
- missions that call for remote, rapid, and precise force application that is both lethal and non-lethal as in preemptive strikes and gaining air superiority,
- responsive, automatic logistics-anywhere, anytime-to minimize large and vulnerable theater deployment,
- reach back with information, in-transit visibility, and point of use delivery,
- weapon system targeting and retargeting while enroute anywhere on the globe.

Successful accomplishment of these OTH activities assumes:

- connectivity to all platforms-anywhere, anytime-as a necessary condition,
- communications bandwidth appropriate to the task is available when and where needed,
- flexibility in the location and mobility of command support facilities for protection and maximum capability,
- Airborne communications relay nodes to make OTH control of sensors and the flow of data and information a routine matter,
- the communications system will react quickly and accurately to help produce the desired military outcomes in the minimum time.

3.4.4 Organizational Implications. As in industry, the movement toward more information-intensive operations may tend to flatten the military organizational hierarchy. Greater knowledge at all levels, coupled with the desirability of responding to opportunity quickly, should lower the general "cost" of operations. This may be more difficult to realize in the military because of the inherent risk to life but rapid reaction times will not be consistent with extensive decision-making hierarchies.

Command centers of the future may have their components in different locations but will be logically tied to each other and to common databases. This notion makes possible the forward deployment of much smaller command centers. A command element and perhaps a small support staff will always be needed in theater for human interactions with subordinates, commanders, and lateral land, sea, and SOF forces, as well as coalition partners. Much, if not most, of the C2 staff and their work would remain in CONUS, thus significantly lowering the forward footprint of people and equipment.

At the wing and squadron level the trend will continue to be toward fewer numbers of weapon delivery systems with the same or more mobility and lethality than before. Precision delivery of weapons allows the required force structure to go from tens of thousands of B-17s in World War II to a few tens of hundreds of F-16s and F-15Es today. The advent of precision knowledge and weapons and their employment by the C2 system of the future will cause another reduction in force size to a few hundred weapon systems.

3.4.5 Operational Concept Summary. The expectation of this future C2 system is that it will function across the spectrum of military operations, require a global awareness and a detailed knowledge of the battlespace, and use dynamic planning and execution control to fight the war. The system requires over-the-horizon operations that are as natural as line-of-sight. All are necessary to achieve this future vision. Given this operational view of the vision for the C2 system of the future, there now needs to be some discussion of the corresponding support system needed to effectively implement the vision.

3.5 A Simple Model to View Command and Its Support Systems

Obviously, when operating over various regions in the spectrum of conflict, one would not like to have to materially change the C2 support system. Doing so means a greater cost in the time to adapt equipment and information to each new circumstance and, at the very least, a bigger training problem. The interests and functions at the NCA and shooter levels are very different, just as deep interdiction and peacekeeping arc. One way to accommodate these wide variations with one system is to modularize it, changing as little as possible consistent with offering the required functionality.

To make a future C2 system as flexible as possible, the system will be analyzed in two ***major*** parts. Done correctly, this will also show the relationship between the functions of command and the characteristics of its support systems. One part would be a flexible set of tools and information, adapted only where necessary, to the specific conflict or mission in question, and the other part would be invariant across the spectrum of conflicts. This second part would be a common, consistent, and ubiquitous infrastructure ***on*** which to build and operate ***a*** wide range of tools and provide command-relevant information, irrespective of the mission, time, or location.

All modem C2 support systems are computer intensive and, if designed well for this purpose, can be made flexible. The intrinsic networking that links them defines an infrastructure that will be more invariant than its attached components. This invariance will mean that the same computing environment can be set up and operated anywhere the infrastructure extends. That is not to say that all components connected to the infrastructure must be the same but that the interfaces should be. Given the mobility of military forces, much of that infrastructure will be radio-based and, depending on the mobile platform being served, will have different information handling capacities.

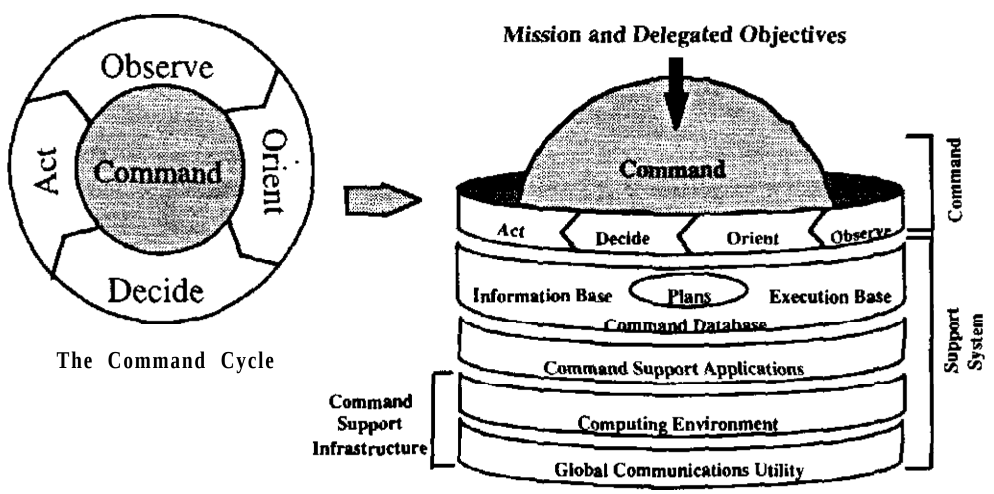


Figure 3-4. C2 System Support Model

Figure 3-4 is intended to provide a simple means to link the functionality of command with the systems that support it. It derives in part from a linear and cyclical representation of command and partly from the notion that modem computing and information systems are best designed in modular layers, most of which can be thought of as supplying a service. The horizontal dimension in the top two layers represents command functions in terms of the familiar OODA loop that contains the continuous planning and execution cycle-the one that must be comfortably shorter than the enemy's The vertical or layered dimension starts with a command database consisting mostly of objects produced by the next lower layer. It is part information intensive, which naturally aligns with the "observe" and "orient" functions above it; part execution orders which define increasingly refined target and task-scheduling information; and plans, which logically link the two databases to together. The model has a number of attributes:

- Separates command from its supporting systems while still linking their functionality. It explicitly relates operational and system architectures.
- Provides an invariant part, the infrastructure, and a variable or adaptive part which comprises the upper three layers.
- The lower the layer, the greater its functional and developmental stability, although all such systems are evolving rapidly.
- Each layer modularly provides a service to the one above it and is thus transparent to non-adjacent ones. This has great, simplifying implications for replacement and upgrading.

3.6 Command Support Applications and the Information They Create

This section will use the above model to direct attention to the characteristics and attributes needed to develop each layer. Because the C2 applications programs are the software that supports the functionality and provides the information the commander needs, the discussion will begin with the two major areas of functional emphasis: global awareness and dynamic planning and execution. These applications are umbrellas that contain a myriad of more detailed functions that drive the planning and command cycles, For the applications and other supporting layers there will also be a list of the many technologies that are critical to developing the functions performed by that level. These are shown in Appendix C. These lists are also annotated as to those that are military unique and therefore not expected to be developed in the commercial marketplace.

3.6.1 Global Awareness Application Programs. This section will deal with the information base that forms the basis for wartime advantage. Two areas will be addressed: the database that contains the information and the sensors that collect the information. The biggest challenge of the first area is creating a single, integrated picture of the battlespace. For the second area, the challenge is directing the collection effort, seeking to detect increasingly difficult targets, and indexing and qualifying the data adequately for its current and future use.

One way to help assure that a large number of joint and coalition forces are operationally integrated is to have but one, consistent information base. For both protection and operational convenience, such a resource will be geographically distributed but logically integrated. It will have recently acquired data from the set of worldwide or theater-intensive sensors but will also contain the ongoing, consolidated pictures based on processed or fused information.

The notion of a single such information source to serve such a wide spectrum of interests requires an ability to provide perspectives or "views" on the set that are limited to the interests or authorization of a given requester or "'viewer." A commander, an aircraft controller, and a pilot all require different views from what is, hopefully, the same information set.

But to create a single integrated picture of the world that has adequate time and spatial resolution in regions of military interest, that has appropriately tailored views that depend upon the role and status of the requester as well as the state of the data, and that can be accessed from anywhere at anytime with little latency is an extremely difficult task, even if the component databases are homogeneous. Although the technical design is difficult, the methods for organizing, accessing, and reentering information are much more formidable. Meeting the needs of disparate sets of users that have a range of priorities and demands will lead to trade-offs and compromises, What considerations and compromises will be made such that the critical parts of such a system will be available when and where needed? From the systems design side, development programs that monitor and, where necessary, supplement commercial database developments will be crucial. Large, complex information bases that offer thousands of corporate users easy access are now appearing in the marketplace. Under the general title of "intranet access," consistent, web-like interfaces are used that hide a lot of heterogeneity, disparate schema, and query languages. Mediators and agent-like database-access translators are also appearing.

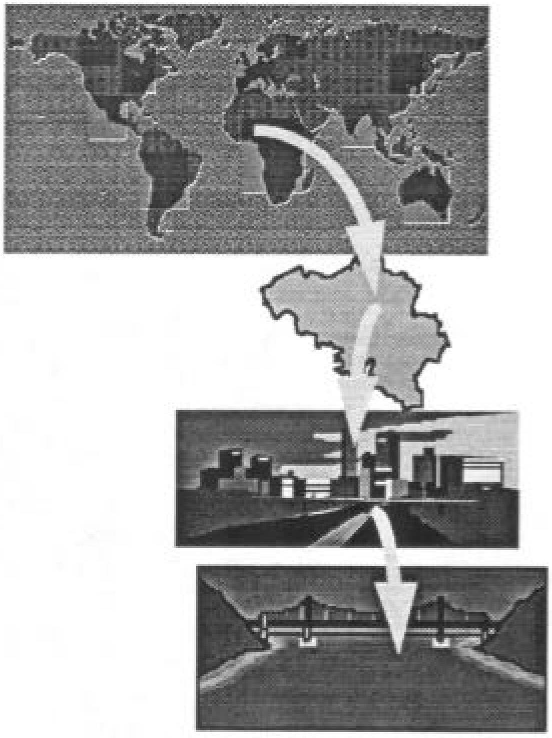
Regarding the sensors themselves, today the US has such a plethora of systems that it is impossible to fully use all the data that is being collected. While that consequence gives some hope that much of the raw material for an information-dominant strategy exists, it leaves the more perplexing question of how it gets processed and used rather than just acquired. Technology can and must help in both areas in the form of better control and location of sensors and the means to deal rapidly and intelligently with the data collected.

The existence of a global infrastructure will enable better sensor deployment (higher frame rate on critical targets) and eventually make possible the separation of sensors from their manned platforms of today. This would give much more latitude to their deployment and endurance. The use of precision weapons requires a corresponding geo-accuracy in current sensing systems. Every pixel should be thought of as having fire-control quality resolution and geo-reference.

So, the program characteristics most critical to developing this part of the application layer include, but are not limited to:

- remote sensor management,
- integrated land, sea, and aerospace picture,
- views tailored to user needs,
- integrated pictures consistent across views,
- imagery data geo-registered; "every pixel a coordinate,"
- powerful fusion "engines" which reconcile/consolidate different sensor inputs and which are both automatic and interactive,
- information dissemination that is provider pushed-as in direct theater or global broadcasting with local information filtering, and user pulled-as in web-like requests,
- sensor and sensor platform management programs controllable from anywhere,
- an urgency of dissemination component that can bring information directly from sensor to decision point (including a shooter) to deal with time-critical targets.

A pictorial view that shows that global awareness actually has a range of sources and interpretations is shown in Figure 3-5.



- **Global Awareness:**
  Dedicated, unique tracking/recognition systems used to support national security
- **Force-Level Picture:**
  Common theater picture produced by distributed mixed initiative tracking/ATR, centralized fusion
- **Mission-Level Picture:**
  Provides situation awareness for the controller managing the execution of the engagement
- **Engagement Picture:**
  Localized, automatic tracking/ATR/fusion based on fire-control quality sensors

Figure 3-5. Global Awareness: Various Pictures or Views

3.6.2 Dynamic Planning and Execution Application Programs. To profit from a superior knowledge of the battlespace requires two critical capabilities: to translate that knowledge into clear, decisive plans, rapidly arrived at, and to manage the execution of those plans even though they may be complex and dynamic. Both the complexity of future plans and the rapidity with which they must be generated and modified mean planning automation is imperative. That automation will also help address the need for real-time and continuous planning and for the evaluations that must accompany any planning activity.

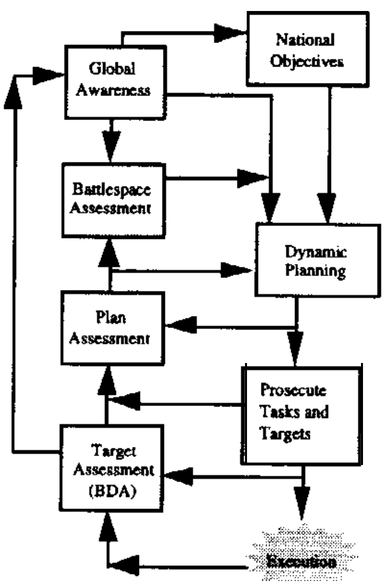
To effectively control the vast resources of a complex military campaign (e.g., processing the target queue) requires that all participants know the present plans and their role in those plans. That is possible only with machine aids that create tasking orders that are clear and unambiguous and with rich connectivity that insures that all participants receive and acknowledge their understanding of them. The success of joint and coalition warfare also requires the extension of the communications infrastructure to all members. Cooperative engagements will not otherwise work.

One of the reasons why the planning and execution phases of command have been integrated here is that for certain important targets the time between awareness and action is extremely short. The efficient prosecution of mobile and fleeting targets requires continuous tracking, sensor and shooter cueing, and reliable and immediate communications. The overall strategy of being able to do more with information than one's adversary comes down to this capability.

So, some key characteristics of future planning systems include:

- real-time, interactive, collaborative planning tools to evaluate and update courses of action that include:
  - ⇒ non-linear, reentrant, and asynchronous planning cycles,
  - ⇒ faster than real-time mission planning,
  - ⇒ rapid rehearsal using modeling and simulation,
- near real-time updates of mission/weapon profiles and BDA,
- dynamically generated tasking orders,
- universal access to required information in the global database,

The employment of the above needs is shown in Figure 3-6 and the accompanying descriptions:



Farce Level:
Plan: Based upon feasible target assignment
Execution: Re-planning based on campaign assessments

Mission Level :
Plan: Scheduling platform for assignments that reflect the prosecution of target queues
Execution: Real-time alterations of the platform/target assignment list to reflect changes in the force-level plan or conditions at the engagement, post-attack BDA for real-time n-engagement

Engagement Level:
Warfighter pre-planned. onboard re-plan, real-time BDA

Response Times:
A tailorable process that lends itself to automation with knowledge databases using goal oriented methods to model and simulate mission objectives in faster than real-time

Figure 3-6. Dynamic Planning and Execution Cycle

3.6.3 General Software Characteristics. Through the continuing evolution of software design and use, there are characteristics that apply to any and all application programs developed for this level. It will be important to use and apply these characteristics to all of the applications to ensure a commonality of design and implementation. Some examples are:

- task-level computing-generally laying above today's normal application programs. Some may appear as task-executing agents,
- heavy use of commercial off-the-shelf (COTS) software, but some military-unique programs must be defined and developed (see Appendix C),

- application programs that scale compatibly to the echelon of use, communications characteristics, and the size of computer on which they are used,
- commonality among planning and other C2 programs to reduce their total number and their maintenance and training requirements,
- time-critical functionality derived from software, wherever possible,
- tools for training, mission rehearsal, as well as mission execution and outcome.

3.6.4 Command Support Database-System Characteristics. The information or database level houses the preferential knowledge about enemy and friendly forces as well as the plans and orders that can give the commander decisive leverage. Its timeliness and accuracy are fundamental to the success of the C2 system. Entering and withdrawing information from this database, independent of where the data and user are located, form the basis for the collection, use, and dissemination of all C2 information.

The database will contain a wide variety of material such as target tracks, in-process video, continuously updated maps, the traditional "--ints," translated speech and documents, simulation results and predictions, as well as publicly available, open-source reports. But, in spite of the latitude of such data and information, it is important that the information represents a common picture to the viewers. Creating that consistency between views will be the most difficult undertaking of all, considering that the summarized and fused information will have to carry some quality index. One illustration of how a common picture comes together is shown in Figure 3-7.

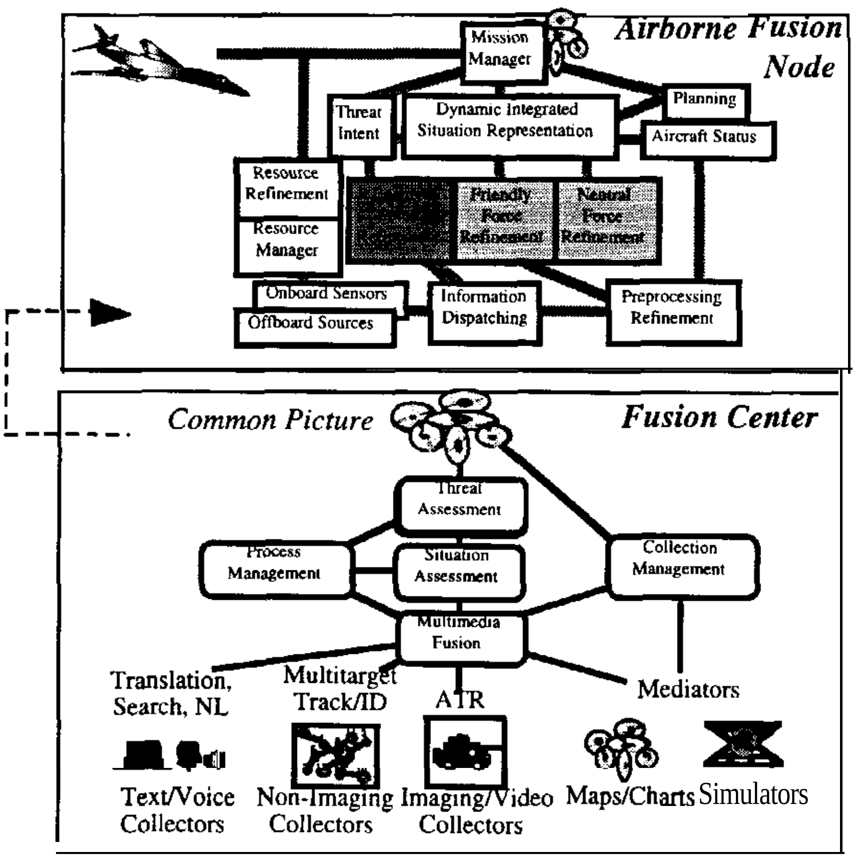


Figure 3-7. Production and Airborne Use of the Common Picture

Since all information is contained in this logical database, great care must be used in its design to both yield the appropriate information to those authorized and to deny inappropriate information to those who are not. Part of the protection will come from its not being just one physical database (and not even necessarily the same database management system) in one location, but a distributed database located in those places most appropriate for the task and mission at hand. Some critical characteristics are outline below.

- Distributed and integrated so as to:

  ⇒ provide multiple and different views definable by the user, information-retrieval templates, or software agents,

  ⇒ establish a common time and geo-spatial reference grid,

  ⇒ use standard data elements and pedigree of objects,

  ⇒ employ common, platform-independent query languages or web-like overlays,

  ⇒ be scaleable, consistent, and concurrent.

- Dissemination that offers broadcast-like push with local filtering and selectivity, and user-selected pull, manual or automatic.

- Database management systems that are single, scaleable, consistent, and concurrent; multi-level secure and access authorization protected; and consistent with retrieval strategies for imagery and embedded objects.

- Strategies for model-based exploitation of image features and change detection,

3.6.5 Common Computing Environment—System Characteristics. This level of the model is the computing environment, both hardware and software, that is necessary to support both the database management systems and all of the applications programs needed for global awareness and dynamic planning and execution, This is the level at which the GCCS or DII Common Operating Environment specifications and applications would be found. Specifically, this level would:

- consist of computers, operating systems, middleware, and utilities that:

  ⇒ are modular with upgradeable/replaceable components,

  ⇒ are able to automatically scale information to the size and computational power of connected computers,

  ⇒ arc interoperable from the use of open and platform-independent software,

  ⇒ allow for human-computer interaction with multiple modalities adaptable to tasks and users,

  ⇒ are location-independent,

- have assured availability of distributed (virtual) assets through:

⇒ redundant networks and databases with self-monitoring and fault-tolerant attributes,

⇒ distributed system utilities for remote log-in, tile transfer, directory services, compression,

⇒ military-sanctioned security capabilities of embedded encryption, access control, authentication, key management, and secure subnet creation,

⇒ software that supports distributed, fault-tolerant tasking across multiple, networked platforms,

- provide human-computer interaction with multiple modalities adaptable to both tasks and users (i.e., common domains have common look and feel),
- use high-level, platform-independent languages to simplify the access and transfer of information,
- employ program and hardware modularity,
- develop middleware-based agents that set up and negotiate for information needed by many of the middleware actions,
- provide office software utilities such as email and conferencing for data, voice, and video network connections,
- provide interoperability that derives more from open systems and platform-independent software than from homogeneous platforms.

3.6.6 Global Communications Utility-System Characteristics. Communication is the linchpin that holds all resources together. As the bottom layer of the future model it must provide a wide range of communications capabilities and services across multiple transmission media to achieve total connectivity. The rapid and adaptive execution of complex missions will require over-the-horizon linkages between warfighters and their information and control nodes. The results will be a communications infrastructure in which all platforms and players are connected with enough bandwidth to conduct business anywhere, anytime.

A look inside this global infosphere would find that the communication capability will consist of such things as robust, multiband, wireless links to remote tactical nodes for voice and varying forms of data, relays such as satellites, and Uninhabited Aerial Vehicles (UAV's), digitally programmable radios, low cost antennas, worldwide connection to air fleet using military and commercial satellites, point-to-point and global broadcast, and lightweight, compact, low power, deployable, commercially produced communications equipment such as routers, switches, and gateways. The long haul backbone will be a mix of fiber optics and satellites, both military and commercial. The most noticeable requirements and characteristics arc:

- joint and interoperable through:

⇒ leveraging the best commercial practices,

⇒ using open conventions and standards,

⇒ using common theater-level or medium area nets,

⇒ using worldwide commercial fiber optic or satellite backbone with guaranteed performance and gigabit to terabit capacities,

- instant, integrated, scaleable infrastructure providing:

  ⇒ worldwide connection to mobile platforms using commercial and military assets,

  ⇒ quality-of-service including priority and security,

  ⇒ distributed collaboration, confercncing utilities,

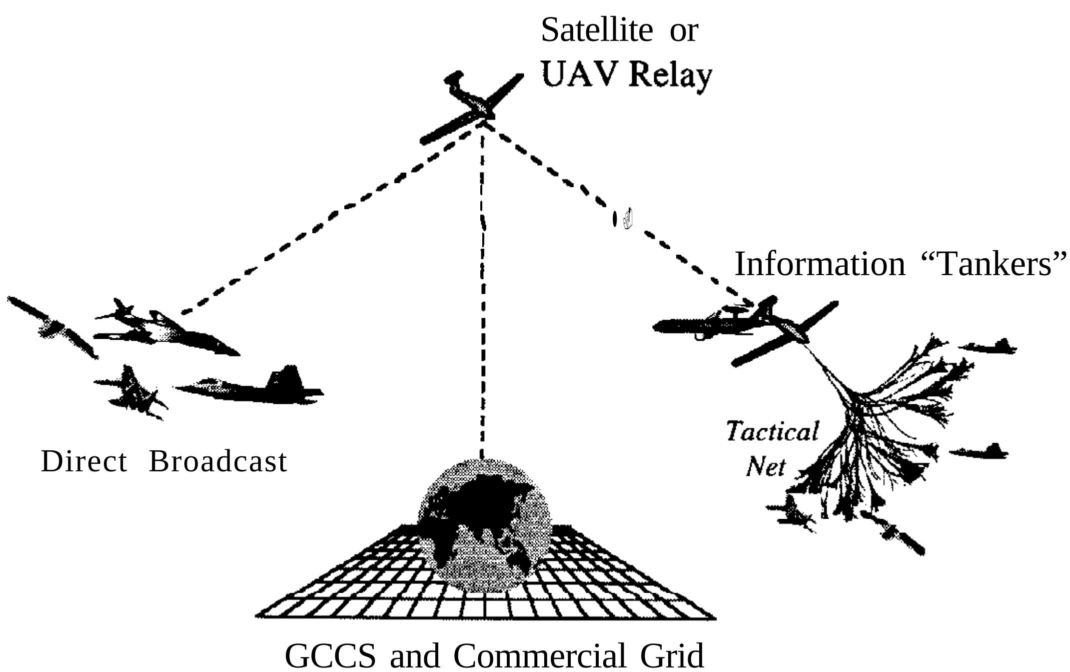


Figure 3-8. Mobile Connectivity to the Global Communication Grid

- assured availability, adequate surge capacity, and high utilization using:

  ⇒ system-wide network management and adaptive routing,

  ⇒ redundancy and alternate routing at all points of a physical circuit,

- critical, military-unique equipment and software that may not be commercially available, such as:

  ⇒ aircraft antennae for over-the-horizon connectivity; satellite systems with anti-jam capability,

  ⇒ translators to non-standard systems such as for coalition forces,

⇒ digitally controlled multi-band transceivers for dynamic network topology and link capacity,

- DoD-accredited, secure virtual (location-independent) subnets,

- adaptive, link-level antenna nulling and other jam-resistance that trades off capacity for protection,

- system-wide network management with monitoring, testing, load balancing, priority for network diagnostics, preemption, and fault detection, isolation, and recovery.

3.6.7 System Characteristics Summary. By using this model, it has been shown that each layer builds upon the next to enable the execution of the future C2 vision. While each layer can be discussed in isolation, they must all work together for a total system solution of C2. The summary of each layer is depicted in Figure 3-9.

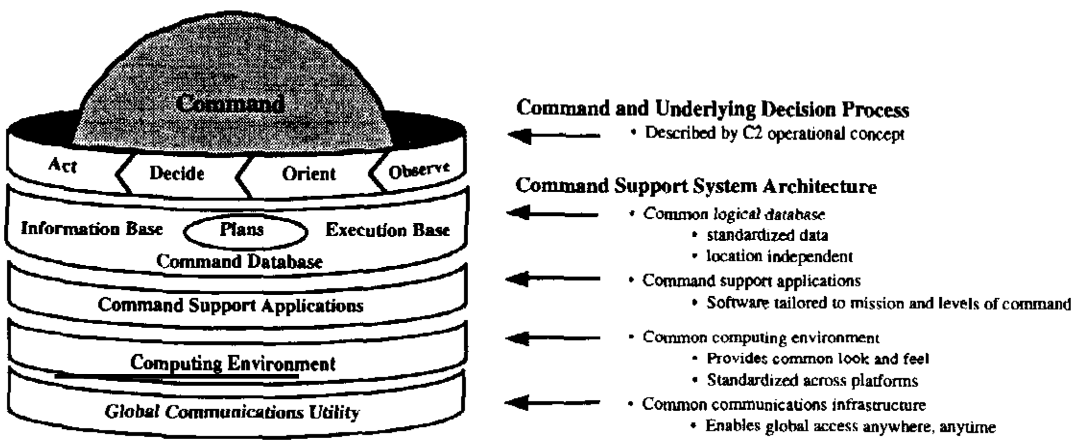


Figure 3-9. System Characteristics Summary

Characteristics of the C2 system for the future can be summarized in the following statements:

- Supports all levels of military operations, anywhere, anytime.

- Provides global, force, mission, and engagement levels of awareness with views appropriate to each.

- Has increased accuracy and availability of information-a near-perfect knowledge of the battlefield, able to be disseminated in real time.

- Enables dynamic planning and execution from observation through retargeting with the ability to change plans in real time, including time-critical targets.

- Provides a consistent and ubiquitous connecting infrastructure upon which any C2 capability can be rapidly constructed, including a logical, integrated database that is accessible worldwide and a consistent computing environment that permits renewal.

- Has a robust, interoperable connectivity both locally and beyond the horizon.

- Has lower cost of operations and development-greater automation, continued progress toward commercial standards and hardware, increased adoption of the best commercial practice in software.
- Has tightened joint/agency/coalition relationships for operations and development-heavy involvement in joint/agency information systems projects and heavy participation in the ACTD process.
- Focuses on core competencies-representing the Services' contribution to the overall pool of national C2 systems.

There are a number of questions and issues relating to the C2 system as discussed. To mention just a few: How does one solve the need to reconcile an extremely large database that has disparate sources, heterogeneous components, and mixes of time-critical and archival data? How does the database get managed to include the collection resources that serve as major inputs? Where does fusion best take place, given its importance to cycle time, bandwidth, and location of collectors and users? Do there need to be consistency checks against complex plans or tasking orders, across both vertical and horizontal counterparts? Is there a useful distinction to be made between "plans" and "orders?" Who or what defines the one geo-reference system? Will there be a military "intranet" and is it a physically separate and distinct network? Who guarantees quality-of-service in a heterogeneous net (some commercial, some military), including availability? How do the extremely difficult detection and tracking requirements of guerrilla- and terrorist-like activities get served by a suite of sensor systems and other intelligence?

These questions and issues, along with numerous others, can and need to be addressed through the development and migration of systems and products through Advanced Concept Technology Demonstrations, especially for those items that will not be commercially developed. Some of the more pressing actions that are first steps in reaching the C2 system of the future are:

- Developing an open tactical network that connects aircraft over long distances via satellite and UAV relay to surface C2 networks. Key technologies are low cost pointing antennas, software radios, and intemet protocols for mobile airborne users.
- Developing automated planning tools that support a nonlinear, asynchronous, rapid style of air operations.
- Developing the software aides that permit end users (commanders, controllers, aircrews) to effectively access and use network-based information and collaboration.
- Improving sensor frame rate, geo-accuracy, and resolution. Evolve toward fire-control quality for offboard sensors.
- Developing an integrated fusion architecture consistent across every layer of command (commander, controller, cockpit).
- Developing the algorithms that support automatic fusion and automatic target recognition.
- Developing an integrated C2 architecture that is open to Joint users, permitting cooperative planning and cooperative engagements across a spectrum of missions.

The proposed migration strategy is discussed in Chapter 4 where the focus is on actual systems, products, and technologies that need to change and develop if the C2 future vision is to be reached by 2025.

Chapter 4

Migration Strategy

4.1 Introduction

This chapter establishes a migration strategy to evolve current aerospace C2 systems to meet the objectives and goals presented on the Vision of Aerospace C2 for the 21st Century described in Chapter 3.

The primary challenge was to examine the current C2 configuration in the light of criteria that characterize the Vision. The resulting shortfalls are addressed based on available mitigating technologies, affordability, and mission impact.

This discussion proposes a migration path and provides some specific first steps to begin that migration. Individual programs and systems were examined with the intention of providing specific recommendations on what new activities need to start, what ongoing activities should be stopped, and what programs should be modified.

Program adjustments were considered from the very near term-as early as December 1996through 2000, with some placeholders through 2025. The study panels avoided specific cost and detailed schedule predictions, leaving these exercises to program development activities.

Six specific Advanced Concept Technology Demonstrations (ACTDs) are proposed as modest investments that could reduce programmatic risk by demonstrating emerging technologies in the context of the operational concepts by which they would be employed.

In the approach to the problem, a consistent, pervasive issue was found that deserved special mention. This was the very complex problem of bringing sensor-derived data from National and tactical systems into geospatially aligned and fused data. Furthermore, the underlying theme of the report was placed in the context of the OODA decision process described previously.

4.2 Assumptions and Assessments

4.2.1 Assumptions. A set of assumptions that will guide this migration strategy has been established based on the assessment of future military operations and their impact on aerospace C2 systems in Chapter 1. These assumptions are summarized below.

- The Air Force will continue to evolve into a CONUS-based power projection force and will not have a large forward-deployed presence in any of the areas where force may be used.

- The Air Force will strive to reduce its in-theater support footprint. Any functions that do not have to be performed in theater will be done at alternate locations, either at the AOC or in regional operations centers or CONUS locations. This split operational theme will be highly dependent on long-haul communications featuring increasingly higher information transfer rates.

- A national concern of minimizing risk to human life will be a factor in future operations. This will continue to be a major issue for political, national, and public support, extending from peacekeeping and Operations Other Than War (OOTW) to fighting a Major Regional Conflict (MRC). Strategies reducing or eliminating the risk to human beings include demonstrations and follow-on programs to remote many of the functions of "back-end" crews on airborne platforms to ground stations outside the AOR and the extensive use of Unmanned Aerial

Vehicles (UAVs). These initiatives will also develop the necessary operational concepts that allow future migration of sensors and surveillance systems to UAV and space platforms.

- The conventional threat environment will continue to increase, and rapidly developing, commercially available technologies will have the potential of "leveling the playing field" in many critical, information mission areas. Enemies and unaligned actors may well have C2 capabilities comparable or more advanced than those of allied forces. In some cases, traditional factors of surprise that keep an adversary off-balance may be completely mitigated by technically advanced news gathering agencies and targeted commercial reconnaissance systems.

- Weapons of mass destruction (WMD) will continue to proliferate. The need for accurate and timely knowledge of weapons technology, targeting tactics, and containment of WMD will be a battlefield priority.

- The defense budget will continue to decline and very little money will be available for new-start programs. New programs will have to be funded by canceling or downsizing existing programs.

- Space operations will remain expensive. The Air Force should expect continued though modest growth in space applications. Despite continual increases in space technology and proliferated commercial space investment, the focus through 2025 will remain on improvements to situational awareness and communications. For example, despite the technical feasibility of space-based radar surveillance systems for imaging and moving target tracking, the technology and investment for such a system makes short term fielding unlikely. Near term strategy will be to exploit existing capabilities to the maximum, augmenting space-based systems with UAV platforms where appropriate to increase capacity and relieve coverage shortfalls, and where in-theater assets may be preferable, for intrabattlespace sensing and communications.

- ACTDs will offer excellent opportunities as logical first steps to begin movement toward the Vision. They will reduce technology risk while developing complementary operational concepts. Funding can come from both the operational and development communities. The rapid turn-over of information technology life-cycles is suited to the rapid development pace of an ACTD with alternative discovery as an objective.

4.2.2 Operational Needs Assessment. The following tasks were found most operationally relevant regarding supporting technologies. The assessments were established by the processes discussed in Chapter 2.

- Enable real-time situational awareness and targeting by theater-wide sensor data, fused together for a clearer understanding of tbe operational situation. Ensure data form, pedigree, storage, and access from which users can create consistent, correlated and integrated, collaborative "pictures" of their domain-specific mission objectives and threats.

- Establish the means to provide this information into decision support tools to add center of gravity analysis covering strategic, operational, and tactical actions, including both friend and foe.

- Develop modeling and simulation capability for execution analysis to "fly the missions ahead of time."

- Enable robust communications with over-the-horizon connectivity to open up operations by extending the Commander's control both into and out of the theater, and into and out of the cockpit. Increase operational flexibility, force survivability, and dynamic retasking beyond current line of sight limits.

- Facilitate system employment with minimum footprint.

4.3 Approach to the Problem

4.3.1 OODA Process Model. The migration plan is baselined to a functional approach by relating each objective to the OODA Process Model.

- Observe. Observation is accomplished by sensors, surveillance systems, and intelligence community products as well as by systems that characterize disposition of friendly and other forces. The root problem of "observation" lies in getting the information from the sensors into the decision systems and weapons platforms-at the right time and in the right format. While Air Force executive guidance directs the movement of these observing functions to space, this goal appears long term and costly at the present. Size and weight reductions in the deployed force structure (frequently referred to as "footprint") and advancement of long-life, radiation-hardened, high capacity power systems for future space-based sensors and surveillance systems (such as space-based radar) are priorities for science and technology (S&T) investment.

  Current observations systems include: Airborne Warning and Control System (AWACS), Joint Surveillance Target Attack Radar System (JSTARS), U-2, Rivet Joint, National systems, on-board sensors, Space-Based Infrared System (SBIRS), environmental sensor/data systems such as Global Weather Central (GWC), Defense Meteorological Satellite Program (DMSP), Polar Orbiting Environmental System (POES), and ground-based tactical air control system Modular Control Element (MCE) TPS-75 radar. The number and types of sensors were found to be sufficient, although improved sensors will be required where camouflage, concealment, and deception techniques are being applied. What is missing is a robust communications and information management capability that can tie diverse and geographically separated sensor platforms to appropriate C2 nodes and to deliver this comprehensive battlespace picture to operational and planning elements at all echelons in the ground, maritime, air, and space domains.

- Orient. Orienting includes correlation, fusion, filtering, tailoring, and display to provide situational awareness. To meet the various information context needs of decision elements at many levels of command, adaptive and tailorable views of a common, coherent, consistent data structure (picture) are required. Current Orienting Systems include: JFACC Situational Awareness System (JSAS)-like systems, Battlefield Situation Display (BSD), Air Force Mission Support System (AFMSS), Contingency Theater Automated Planning System (CTAPS), Combat Intelligence System (CIS), and Global Command and Control System (GCCS). Systems for orientation are also imbedded within multi-role C2 platforms such as AWACS, Airborne Command and Control Center (ABCCC), and JSTARS. These multi-mission platforms contain elements of sensor {observe), fusion (orient), decision aids (decide), and force direction/execution monitoring (act).

- Decide. Deciding includes course of action development, formulation of rules of engagement, simulation of outcomes and mission rehearsal, knowledge of the adversary and friendly/neutral capabilities and intentions, and target recognition capabilities, Human decision assistance algorithms could facilitate improvement in this process. For example, simulations of alternative courses of action which play through the anticipated enemy force reaction and engagement or battle outcomes would be useful in selecting among courses of action or mitigating course of action shortcomings, Current Decision Support Tools include: JSAS-like systems including BSD, Joint Maritime Command Information System (JMCIS), AFMSS, CTAPS, CIS, and GCCS. Multi-role platforms such **as AWACS, MCE, ABCCC,** and JSTARS also feature decision support systems to aid controllers and surveillance technicians in accomplishing their tasks.

- Act. Acting includes the activities of monitoring and adjusting in near-real-time mission execution. Acting includes effective fire control and attack assessment to the engagement element (flight/weapon platform), the mission control function, and the force level execution monitoring activity. Current act systems include: Theater Deployed Communications (TDC), Link 16, multi-role platforms such as ABCCC, AWACS, MCE, and JSTARS.

To a large extent, connectivity among these platforms employs predominantly voice-based communications systems. Accelerated migration towards data link communications is a primary means of achieving distributed situational awareness while providing weapons direction. In addition, there were some supporting connectivity tools/programs which did not directly support or were only partially exploited within the "Act" portion of the OODA loop today, but which were necessary for mission support. These included: MILSATCOM, COMSAT, TDC, Link 16, Common Data Link (CDL), Global Broadcast Service (GBS), Base Information Infrastructure (BII), and Integrated Broadcast Service (IBS)/Tactical and Related Applications (TRAP)/Tactical Information Broadcast Service (TIBS)/Constant Source (CS).

Most of these systems support data distribution. While MILSATCOM systems can and should be applied to the operational communications problem and are being effectively applied within the Special Operations community, shortfalls in compatible avionics and in available capacity have deterred further exploitation of these capabilities. This shortfall is addressed within the overall migration strategy with a long term recommendation for the USAF to better integrate both UHF and survivable EHF communications into its global reach platforms.

4.3.2 Sensor Database Development. A major issue is making sense of the huge quantity of data that is needed to establish the information bases and battlespace awareness that drive the computational and display systems of the current C2 architecture. Additional concerns involve how the information is obtained from disparate systems, in their different formats, for different mission applications, and how all this is done in a timely manner, Specific data input issues examined included the following:

- Information Update/Revisit Rates. How quickly does the wartighter need updated information? Does the update rate need to change as the mission progresses? Current systems do not provide updates fast enough (or the competition for and tasking of these systems may not ensure timely information) to meet the operational requirements, particularly BDA requirements.

- Fusion. Effective fusion reduces or eliminates ambiguity, improves geospatial accuracy, and provides control over the detail, context, and scope of battlespace awareness. For example, a fusion system must determine if two tracks are actually the same target and associate those tracks with combat identification data, resulting in the ability to identify friendly, hostile, and neutral actors within the battlespace. Furthermore, fusion should provide control over display scope/context/level of detail appropriate for the specific mission. This is the ability to tailor and focus information to specific purpose at a specific time. An important requirement of effective fusion is a consistent geospatial, time, and attribute system.

- Sensor Range and Dwell Time of the C2 and Shooter Elements. Key issues include the following questions: Does the sensor spend enough time over the target to gather all the necessary information? Does the "tether" to the ground station limit the sensor's flexibility in extending the operational commander's reach? Does the C2 platform provide an adequate view into the battlespace? Can the shooters obtain data from the C2 platform?

- Tareet Identification. Identification Friend or Foe (IFF), and Combat Identification (ID). These capabilities aid in classifying objects within the battlespace by cooperatively and non-cooperatively identifying force elements as friendly, non-aligned, adversary, or unknown.

- Maritime. Ground. Air. and Space Order of Battle (OB). This consists of an integrated, common, coherent, consistent data (picture) of the battlespace as well as historical and future projected alternative pictures that are updated near-real-time to show how the OB is evolving.

4.4 Migration Plan

4.4.1 Migration Plan Tenets. Based on operational needs, five basic tenets were found most relevant to improving functional performance within the OODA construct. These were used to guide the migration plan development. These tenets are:

- developing robust and flexible OTH/beyond line of sight (BLOS) communications connectivity,

- improving and expanding data and data link use to include exploiting commercial service via military to commercial service gateways,

- improving sensor data availability, computing, and information fusion,

- decreasing the decision cycle time and increasing the decision cycle quality at all levels of command,

- reducing the number of in-theater personnel and their deployment operations tempo.

4.4.2 Migration Strategy. The migration strategy combines the tenants into four general enhancement categories divided as follows:

- Communication/Connectivity,

- Decision Support Tools,

- Logistics, Sustainment, and Mobility,

- Airborne and Space-Based Operations.

4.4.2.1 Communications/Connectivity

Over the years, Air Force communications systems have not kept pace with weapon system and sensor technologies. Extensive investment in space communications in the form of a wide array of military satellite communications (MILSATCOM) has neither been integrated to support existing combat forces nor been postured for evolutionary incorporation into future platforms or force structure. Today's communications capabilities have built upon legacy equipment and, in many cases, World War II operating concepts. Where equipment has been modernized, it has been more to automate manual processes rather than to significantly improve functional warfighting capabilities.

At the same time, commercial sector technologies have advanced several generations, moving from analog voice to digital voice and from 45 word per minute telegraphy and teletype to high speed imaging and facsimile. Data rates have evolved from tens of characters per minute to billions of characters per second as transport mechanisms evolved from copper wire lines to wide-band radio, satellite, and fiber optic-based communications systems. Despite these advances, Air Force air operations within this regime were dominated by ultra high frequency (UHF) analog air-to-ground-to-air (AGA) links. While HAVE QUICK has provided improved robustness by digitizing and applying electronic counter-counter measure (ECCM) techniques to tactical voice operations, the UHF AGA services remained a short-range voice communication link with limited functional advantages over Korean War vintage communications systems. In fact, the use of UHF frequencies for communications provided only modest reduction in interference and little additional functionality over the HF radios of WWII while decreasing range to fine of sight.

Air-to-ground operations are dangerously precarious. Air-to-ground operations use unprotected voice radios using very high frequency (VHF) and frequency modulation (FM) radio links. Army and Marine forces have a similar capability to HAVE QUICK functionality in their VHF frequency spectrum, the single channel ground-to-air radio system (SINCGARS). Although it provides ECCM protection, communications security, and limited data transmission capability, few Air Force aircraft are equipped to interoperate with ground forces. Furthermore, the restrictive channelization and clear/secure/ECCM modes of these UHF and VHF radio systems produce a complex operating environment with abundant collateral interference and a resulting high potential for a major breakdown in C2.

- Recommendation—Digital Data Link. The Air Force should move away from the heavy reliance on voice communications, especially to the cockpit, and move to more capable, linked data systems such as Link 16.

  ⇒ Link 16 compatible terminal equipment that will inter-network C2, sensor, surveillance, and weapons platforms and provide near-term interoperability among the Navy, Marines, and USAF.

  ⇒ Availability of a ubiquitous, digital utility linking platform in the battlespace offers the additional potential for tapping and sharing the rich variety of on-board sensor systems in tactical aircraft.

  ⇒ The ability to track atmospheric pressure and temperature across the battlespace alone offers the potential for much greater understanding of weather phenomenology.

  ⇒ The back link, redistribution, and collaborative sharing of radar warning receiver (RWR), radar, Forward Looking Infrared Radar (FLIR), gun camera, and electronic warfare (EW) sensors can provide additional eyes and ears in the battlespace that can add heretofore unexploited detail and aid in every facet of battle planning and execution, from tactical routing to battle damage assessment.

  ⇒ Availability of back link connectivity would afford use of spectroscopy and other hyperspectral sensing for shoot-look-shoot real-time BDA.

  ⇒ The Air Force should adopt a formal requirement for back-linked information from all air platforms (including the F-22).

  - Steps. Link 16 fielding should be accelerated.

    ⇒ The entire fleet of Air Force aircraft should be made data link capable-including trainers, UAVs, and helicopters.

⇒ Combat and combat support platforms should be equipped within the next 6 years. This objective would diminish the pilot's workload and task saturation potential and improve mission functionality.

⇒ Operational concepts along with human interface designs should be developed that improve interaction among control element (AWACS, ABCCC, JSTARS, AOC, ASOC, TALC) functions and weapons delivery platforms (bombers, fighters, airlift).

⇒ This fielding should also facilitate an operational concept evolution that would enable certain sets of data to be passed directly to individual weapons for employment.

⇒ This plan requires increased investment for Link 16 on aircraft and ground-based platforms/centers/stations by FY99 and a concerted effort to "productize" SPEAKEASY technology into an affordable Link 16-capable system.

- Additional Steps. TIBS/Tactical and Related Applications (TRAP) capability should be employed on all airborne command, control, and communication (C3) platforms. Recent JCS endorsement of this plan in the FY96 Air Force AWACS budget should be addressed to ensure all AWACS and JSTARS aircraft are equipped with this capability.

- Recommendation-Interonerabilitv Standards. At the same time, it is not likely that Link 16 is the long term answer to real-time data communications needs. A prudent investment strategy could exploit the existing interoperability standards while laying the foundation for future advances that will eliminate some of Link 16's capacity and network generation shortfalls while providing a capability to extend survivable, stealthy au-to-an data links via UAV and space communications relay.

⇒ In the long run. the data-link needs will outgrow the capabilities of Link 16, and thus a requirement exists for an Air Operations Data Link-an advanced, adaptive data waveform that would be capable of passing large quantities of battlespace awareness information and would support automatic network establishment with self-healing response to failures and changes in network membership.

⇒ The advanced data link would support functions for exchanging mission planning information among long range strike forces and strategic mobility operations as well as support real-time weapons guidance, directly from "off-board" sensors across the traditional seams in military operations (air, ground, naval, and space).

⇒ Link 16 network topology is limited by "dog collars" and node "choke points" whose capacity may be exceeded by operational demands even before the system can be fully fielded. Moving into the world of data links should not be delayed by any further postponement of Link 16 fielding. But at the same time, work on a more capable waveform should begin immediately.

- Recommendation-Platform Avionics, Beyond immediate Link 16 deployment, exploding, dynamic information technologies demand a flexible, long-term investment strategy in platform avionics. There are many alternative futures for cockpit communications, and the current technical architecture, which employs unique communications and navigation avionics to meet specific requirements, seems ill advised, especially given the availability of flexible communications and computing products that can emulate legacy communications links while providing opportunity for smooth migration to new communications methods and network topologies. Cockpit communications gridlock and competition for space, power, cooling, and data bus resources is near at hand, in those few cases where it has not already been reached.

⇒ Ongoing efforts include fielding Global Positioning System (GPS) receivers, as well as GPS adjuncts for improved precision for area and terminal navigation (e.g., wide area and terminal differential GPS).

⇒ Combat identification systems ranging from Position Location Reporting System (PLRS) and Enhanced PLRS (EPLRS) to follow-on IFF and Combat ID will require additional avionics packages.

⇒ Furthermore, cooperative position reporting for civil air navigation will further complicate the communications picture.

- <u>Recommendation—field programmable Waveforms</u> and and control communications requirements was examined, as well as the underpinning functional connectivity needs. Most of today's systems are "stovepipes" that facilitate system-specific information, including unique data constructs, communications nodes and applications environments, Moreover, mission-specific stovepipes cross the radio frequency spectrum with a bewildering variety of waveforms: UHF AM A/G/A, HAVE QUICK, VHF FM, SINCGARS, Integrated Data Modem (IDM), Instrument Landing System (ILS), GPS, JTIDS/Link 16, Link 11, Link 22, TADIXS-B, OTCIXS, High Frequency Single Side Band (HF SSB), Mode C/S, Combat Identification (CID), IFF, Radar Warning Receiver (RWR), Situational Awareness Data Link (SADL), EPLRS, TIBS/TRAP/IBS, GBS and commercial systems. The Air Force needs an adaptive, affordable approach that will facilitate an "elegant" evolution to new mission needs (frequencies and waveforms) while providing a backward compatibility with legacy and coalition systems.

⇒ Programmable waveform communications processing technology will become essential to airborne platform investment strategy.

⇒ This demonstrated technology is extensible into communications links, including Link 16, Milstar. and commercial-based and personal communications systems (Iridium, Orbcom, Globalstar. Teledesic).

⇒ Technology afforded by the programmable waveform devices should facilitate a "graceful" migration to more capable, follow-on data waveforms while providing interface flexibility to legacy and coalition systems,

⇒ Once on this course, the full exploitation of the technology requires advancement and investment in improved antenna technology.

⇒ Specific areas of investigation include communications techniques that complement stealth technology and afford extended range, two-way communications with stealthy platforms.

⇒ The long-range plan should include economic production of wideband, conformal antenna array systems with nulling for ECCM and narrow beam-widths for LPD/LPI.

⇒ The MILSTAR waveform is one of many candidates for this stealthy application, providing both ECCM and LPI/LPD features in a proven communications package.

- Recommendation—Extend Global Connectivity. One concept that appeared exceptionally attractive to examining the programmable waveform technology in the context of an operational system was to marry the SPEAKEASY program with a communications-like UAV.

  ⇒ The goal would be to extend the Air Force's global connectivity while providing a logical, risk reducing "first step" toward more robust space operations.

  ⇒ Operational concepts developed for UAV operations could then be extended to space at an affordable pace.

  ⇒ The SPEAKEASY program technologies should be incorporated in other mission areas

  ⇒ Highly lucrative uses include Link 16 waveform adaptation and cross-domain ***operations*** (air-to-surface operations).

  ⇒ The SPEAKEASY payload on a Tier 2+ UAV orbiting 65,000 feet in the battlespace would provide a rapidly taskable, reconfigurable communications utility to VHF, UHF, Link 16, and MILSATCOM relay-a pseudosatellite that hovers anyplace in the battesphere.

- Recommendation—Commercial Communications.ations systems will have a significant impact on future military operations. Programs designed to leverage military use of these emerging systems should begin immediately.

  ⇒ At a minimum, "gateways" into Iridium, Global Star, and Teledesic programs should be procured, license agreements should be negotiated, and cooperative technology development undertaken in areas of complementary military needs.

  ⇒ Areas of potential military S&T include information security, exploitation of signals, and high bandwidth capabilities. In particular, the potential to host small, low power military packages on proliferated, networked commercial hosts offers the opportunity for near term, low cost, improvement in tactical communications.

  ⇒ As opportunities to host this programmable waveform technology on networked, low altitude (450-1000 NM) satellites (Teledesic, Iridium, etc.) arise, they should be carefully investigated.

  ⇒ Still, the UAV communications node provides surge and the continued availability of a recoverable test platform for advanced concept demonstration and developmental test before the leap to space.

  ⇒ Commercial and civil space applications will impact military navigation operations. GPS-based Air Traffic Control and Landing System (ATCALS) (using international standards) and the FAA's Future Air Navigation System (FANS) will affect day-to-day operations. Hostile operations will exploit and may deny these systems. Reliable, precise navigation remains a mandatory element of all military operations, but the Global Positioning System redefines precision, making it available to friendly and enemy forces for very modest investment.

  ⇒ Active programs such as the ongoing NAVWAR ACTD that pursue this assured capability are needed.

⇒ Beyond the ACID. however, the Air Force must implement an enduring navigation infrastructure that satisfies all precision navigation needs.

⇒ A UAV-based pseudo-GPS system should be investigated, both as a way of assuring geospatial information to allied forces, and as a means of denying it to any opposition force.

⇒ Moreover, the USAF should increase investment in exploiting GPS for navigation rather than situational awareness purposes. As the commercial and private sector leverage the GPS signal to free their operations from reliance on fixed air routes, the USAF must adapt similar peacetime operating capabilities. The USAF has been slow to avail itself of this tool, despite an infrastructure investment in space navigation that exceeds 10 billion dollars.

- Steps. Direct Broadcast Satellite (DBS) is the latest commercial satellite system available to provide very high speed data broadcasts to small, inexpensive receive only satellite terminals that can be proliferated to any information consumer. The DoD adaptation of DBS is the Global Broadcast Service (GBS). The USAF has been appointed lead service for development and fielding of a GBS for the DoD.

  ⇒ The Air Force should step out and ensure this broad perspective capability is provided to its ground-based and airborne information centers.

  ⇒ The system, through one small antenna, provides information distribution directly to application software.

- Recommendation-Intra-Battlesnace Communications. Communications within the theater of operations need more focused attention. A mom robust intra-theater communications capability should address Joint as well as USAF needs, with the USAF as the "provider" of the capability. The objectives of this program should be to "uncomplicate" the existing patchwork communications nodes, free MILSATCOM channels, extend more capable communications to ground elements, and increase the range of air-to-air and air-to-ground communications. The Air Force must "break me tether" from its present UHF line-of-sight systems.

⇒ A communications relay UAV (as discussed earlier) would provide a viable first step. Operational flexibility of this platform would be obtained by using a programmable digital radio. This affords the opportunity to task and configure the platform for specific mission requirements and operational employment phases.

⇒ The Air Force should examine a mix of high altitude long endurance UAV platforms (Tier 2+/3-) as it investigates operational concepts of the communications program. Both UAV platforms provide a long haul link via commercial satellites, providing intercontinental range extension for reachback from line-of-sight communications links.

⇒ The stealthy characteristics of a Dark Star (Tier 3-) could leverage stealth operations of deep strike B-2, F-l 17, and cruise missile operations while simultaneously providing on-orbit reserve, complementing the Global Hawk (Tier 2+) mission profile.

⇒ The UAV payload can be tied to a controller for communications control, tasking, and inter-networking as well as providing fixed ground entry point services for strategic reachback.

⇒ This communications relay concept evolves smoothly into space-based platforms. As technology allows, the UAV platform and communications payload should be upgraded to provide for Milstar equivalent ECCM robustness on the long haul link.

⇒ Furthermore, Milstar MDR augmentation would provide additional capacity within the theater to support missions ranging from Army MSE extension to LPI communications for small unit operations.

⇒ The flexible and extensible nature of the programmable waveform radio technology that forms the foundation for UAV communications could support both upgrade and advanced technology demonstrations of new waveforms, network methodologies, and information services-both military and commercial.

⇒ Specific attention should be paid to devising methods for all stealth platforms to operate with data waveforms such as Link 16 and the follow-on Air Operations Data Link.

⇒ Milstar capabilities should be revisited to determine and utilize the unique cryptographic links readily available to the Air Force. Milstar already has significant Air Force investment and, with minimal additional investment, will provide significant and secure communications connectivity. Milstar is well suited to the USAF's needs for stealthy communications to match its reduced radar cross-section platforms.

- Recommendation-Inter-Theater Communications. Operational capabilities enabled by improved inter-theater communications could be realized in the near term by working to achieve a reduced deployed "footprint" and combat support "tail." The Air Force should continue to explore the concept of reachback in areas such as base-level support, theater logistics, Air Operations Center activities, and intelligence support functions.

  - Steps. Inter-theater objectives should include providing more long haul communications capacity and reliability.

  ⇒ Tactical air bases and deployed operational units should exploit commercial satellite communications and terrestrial wide-band services to the extent feasible to ensure needs for increased Capacity are met.

  ⇒ MILSATCOM should not be used unless MILSATCOM-unique characteristics such as US military control or ECCM are absolutely essential for mission success.

  ⇒ If MILSATCOM users have access to commercially leased services, their links should be migrated to these services so that military-controlled bandwidth can be made available for tactical users who may not have ready access to commercial, long haul communications services. There arc many other users that need MILSATCOM access, and there is not enough bandwidth to meet operational needs.

  ⇒ Where coverage is available, Ku and eventually Ka band COMSAT capacity can be leased. It could provide the backbone services that would enable split Air Operations Center and Wing Operations Center operations between theater and CONUS sites.

  ⇒ Systems like the Theater Deployable Communications Light Weight, Multi-band Satellite Terminal can be exploited to provide wide bandwidth communications.

⇒ Where COMSATs may not be available, pseudo-satellites can be created on UAV platforms to provide BLOS links to commercial terrestrial wide-band service points, whether submarine cable, satellite, or land based. These pseudosatellites can use both Ka band "bent-pipe" technologies for high bandwidth and low power over narrow beams and Milstar EHF waveforms for robust ECCM performance.

⇒ The Air Force concept of operations for employing DBS/GBS technologies for "reach-forward" from fixed operating bases into the tactical arena needs to mature.

⇒ The requirement to refresh and distribute situational awareness data, maintain synchronization of large databases, and provide threat broadcasts is well suited to the one-way nature of DBS and GBS technologies.

⇒ The recognized air, ground, maritime, and space picture should be made available on a continuous basis via broadcast systems.

⇒ Careful cost analysis should balance the desire to proliferate GBS data via terrestrial systems. GBS receive terminals should be deployed to the point of use, coupled tightly to the information consuming appliance to avoid the need for massive information repositories and high capacity terrestrial networks within the battlespace.

⇒ These major information repositories are best maintained in the rear where the information owners can keep them updated and rebroadcast updates on demand.

- Theommendation—DAMA. mercial wide-band and personal communications services to the battlespace will provide additional capacity that will satisfy growing needs. However, at the same time, proliferation of communications media and methods further complicates the picture for communications management. To be sure, each technology brings its own unique set of characteristics that affect service quality and performance. For example, the Joint Staff directed UHF Demand Assigned Multiple Access (DAMA) waveform adds absolute communications delay for every bit transmitted, delays that may reduce efficiency of data communications beyond operational relevance and cause voice service impacts. To mitigate this concern, systems must properly account for and design around DAMA's physical limitations. Satellite Communications DAMA (SATCOMDAMA) has been established as the DoD SATCOM standard. SATCOMDAMA provides extended OTH capability and instantaneous global awareness to Battlespace Commanders and alternate locations. However, the Air Force has not yet embraced this key capability on its premiere C3 platforms.

  - Steps

⇒ Increased investments in SATCOM DAMA to provide satellite connectivity to all Joint warfighting forces immediately.

⇒ The Air Force should be leading the way, since AWACS, JSTARS, Rivet Joint, U-2s, and UAVs provide the initial OTH capability.

- Recommendation—Network Architecture. Geosynchronous satellites also impart delays (on the order of 250 milliseconds), and multiple hops to geosynchronous satellites encountered as individual links are tandemed across a communications infrastructure further increase the delay. This delay problem is merely annoying for voice communications beyond a single hop to geosynchronous. However, the delay problem can bring a data network to a grinding halt, despite very low error rates and extremely high link capacities. The "Global Grid" or "Infosphere" problem has other dimensions as well. Different networking schemes demand different link performance. Analog voice is quite tolerant of poor circuit performance. The human brain does a good job of interpolating between drop outs, relying on the built-in redundancy of human language.

However, as voice is digitized and compressed, the quality of the link becomes an important factor. Furthermore, as this circuit is encrypted and multiplexed with other circuits, such factors as bit count integrity become absolutely essential. Fiber optic communications links provide high capacity, extremely low bit error rate communications, where satellite links provide high capacity but power budget-limited bit error rates. Asynchronous Transmission Mode networking strategies work very well on fiber optic links but have great difficulty working over modestly performing (say 10" BER) space based systems, due to a lack of embedded forward error correction.

Beyond the myriad of technical issues surrounding the management and exploitation of a multimedia communications network are a variety of vulnerabilities that range from interdiction and denial to interception, exploitation, and deception. Each link medium has associated vulnerability dimensions and attendant physical (and logical) space over which the vulnerabilities can be exploited. Furthermore, the composite networks' reaction to surge and processes through which low priority taskings are deferred or capacity requirements off-loaded have yet to be strategized.

- Steps. A cohesive and thorough study should be started to define how to generate a comprehensive global communications grid, how it should be managed, what basic interface and service levels it should offer, and how it can be architected to take advantage of its diverse strengths while mitigating its complex and, in some cases, interactive vulnerabilities. An extended blue force vs. red force exercise, under varying communications loads, with military, commercial carrier, and government contractor participation is recommended as a first step toward a better understanding of the issues surrounding the "global grid."

4.4.2.2 Decision Support. As discussed in Chapter 2, the innovative and hard working people in the Air Force have overcome the limitations of present C2 systems and have accomplished their tasked missions exceedingly well. However, the C2 decision support tools must serve future commanders better. First, a few important innovations and process improvements deserve special note. Recent Decision Support improvements have enhanced the Air Component Commander's ability to exercise responsibility and delegate authority. The JFACC Situation Awareness System (JSAS) and the JFACC Planning Tool (JPT) are examples of situation awareness and air planning improvements at the Air Component level in Bosnia. Target development, iterated "live" between the AOC and the executing units, as well as "virtual" area orientations and individual pilot mission rehearsals, were innovative air power firsts as seen in the Bosnia operations. The technology that facilitated these new capabilities was a Defense Mapping Agency-sponsored commercial product-PowerScene. Furthermore, the Air Force has begun a commendable policy of consolidating C2 acquisition under a single program management authority. This is a good start; however, the Air Force must continue to seek ways to improve the process in how it obtains and fields its C2 technology.

The major problem areas addressed in this section of the report fall into the following broad categories. First are operational deficiencies, duplications and inefficiencies, including "competing software architectures, applications, and research," and poor coupling between operational concepts and technology development. Second is poor data integration, including technical incompatibilities and disconnects, neglected coalition operational implications, as well as security, reliability, and pedigree needs. Third is lack of vision, advocacy, and leadership, including insufficient resources and funding, ineffective interaction with the commercial market, and absence of an Air Force advocate. Each will be addressed below.

Operational Deficiencies. Duplications. and Inefficiencies. Connectivity is missing and information is not formatted for use. Deficiencies are obvious at all levels of command-Force, Mission, and Engagement-and most notably flawed in execution operations while duplications abound. The Air Force has fielded and is fielding numerous ground-based systems for orientation and decision support. These include: CTAPS, CIS, Wing Command and Control System (WCCS), Command and Control Information Processing System (C2IPS), Consolidated Aerial Port System (CAPS), AFMSS, Tactical Interim CAMS/REMIS Reporting System (TICCARS)/Core Automated Management System (CAMS)/ Reliability and Maintainability Information System (REMIS), Modular Control Element (MCE), Global Decision Support System (GDSS), Strategic Warfare Planning System (SWPS), Cheyenne Mountain/AOC/Regional Operations Control Center (ROCC)/Sector Operations Control Center (SOCC), Contingency Airborne Reconnaissance System (CARS), and UAV ground stations, as well as the large number of "joint," other Service, and coalition systems that work alongside this collection. As a result, the sheer volume of systems complicates any cohesive system-of-systems mission integration and leads to an unwieldy, unresponsive bureaucracy. Numerous overlapping developments carry a high "opportunity" cost, especially in times of reduced funding. Furthermore, each of these systems exists on various government-developed, individual operating environments, each with its own "standards" and funding stream.

The incentive to "interoperate" and develop a "total system" that is better than the sum of the individual parts is missing. No incentive exists to optimize the information/data flow among the system components. "Fat-fingering" (or data re-entry) abounds. In addition, many of the functions performed by these systems are duplicates of themselves. Several scheduling algorithms exist in various modules within many systems. Mapping and other "services" are different developments in each. Even basic spreadsheet functions are implemented time and again. An example of this duplication deals with AFMSS and SWPS. Both have similar missions with different weapons systems; however, the tools available within these mission planning systems have different functionality despite the needs for close choreography among the various actors in the battlespace.

Inefficiencies in technology application stem from poor coupling between operational concepts and technology development. The technology approach adopted to date has "automated" present inefficient, manpower-intensive operations and has thus seen marginal, if any, improvement in either time taken to perform a task or quality improvements in the effort. Further inefficiencies are found in the way the Air Force laboratories compete for various application projects. The panel members believe that the laboratory's time and money could be much more effectively used by improving the Air Force's leadership role in the commercial standards development process and providing skilled acquisition guidance to AF programs.

Poor Data Integration. The SAB found a lack of vertical integration in all information systems-there arc "tire walls" among systems supporting the various levels of organization through which information can not be passed seamlessly. Despite the apparent logic of tight information coupling among decision support systems, no program to do so was evident. Data from top-level decision support systems such as GCCS and AOC-level systems [CTAPS and eventually Theater Battle Management Core Systems (TBMCS)] consist of text messages, which in most cases have to be re-entered into mission-level systems (AFMSS). Linkages to and from the shooter platforms/weapons to decision support systems at all levels are predominantly "voice only." As an example, operational units could accomplish more effective mission planning if an integrated system brought together battlespace awareness information. Information could be fused from systems such as the BSD, JSAS, and CIS with mission tasking information from TBMCS for mission planning systems (AFMSS) for just such an improved capability. The information capabilities required for "dynamic air tasking" must support automatic mission routing, situation awareness building, "airborne mission fly-through/rehearsal," target refinement, and ultimately weapon guidance and updating from the cockpit. Attack assessment (the feedback mechanism) is especially lacking. BDA is approached primarily as a "force level" activity and as an extension of the "intelligence system" (through collection assets and mission reports). The present system has latencies that make it useless for dynamic planning and precision attack. Despite the critical need for comprehensive assessment support (especially for the coming generation of all-weather, precision munitions), no systematic approach to attack assessment exists. Figure 4-l presents a description of the current attack assessment system.

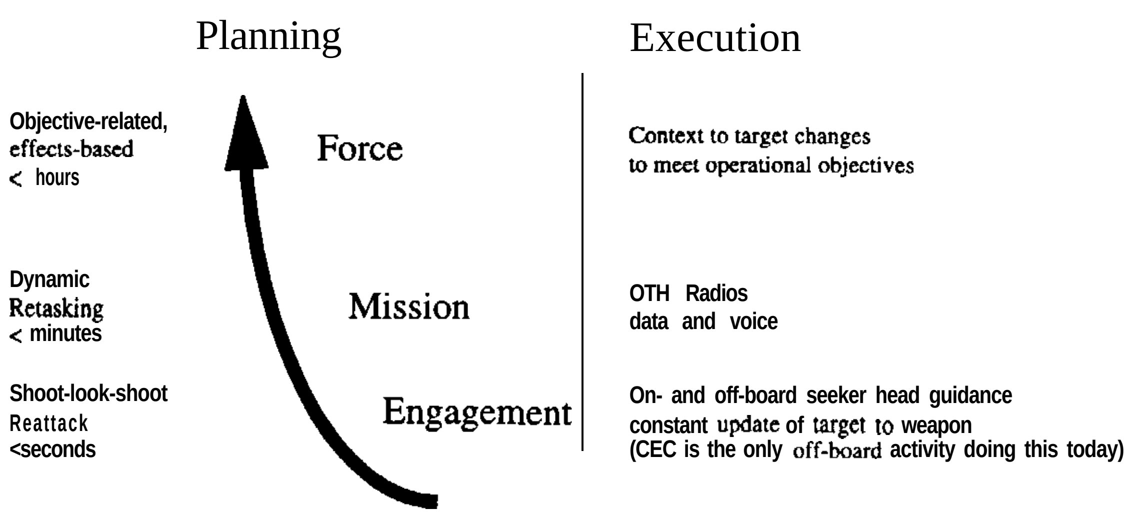


Figure 4-1. Attack Assessment System Description

Standards arc part of the complete answer. Coalition operations and requirements to interface with numerous commercial and developing systems means that simply mandating standards will not by itself fully solve this problem. However, certain core data elements could be standardized along with associated data models, and US C2 systems could be integrated both vertically and horizontally much more effectively than at present. Work in self-describing data elements, system tolerance of incomplete data, incorporation of fuzzy information, and software data agents and "cyber cops" is necessary.

- Recommendations. The Air Force's primary "tool-set" for providing commanders **Orientation** and Decision Support at the Air Operations Center is the TBMCS. The TBMCS package is a second-generation collection of the first-generation automation tools amalgamated under the CTAPS banner plus the Combat Intelligence System (CIS) and the Wing Command and Control System (WCCS). The objective of TBMCS is to collect the various pieces of "functional" code, clean it up, modularize it, and place it within a modem, object-oriented architecture that is GCCS compliant. Restructuring the code to match more effectively with re-engineered operational concepts has not received emphasis. Only cycle time reductions of the present processes are stated objectives of the program.

  ⇒ Although not as ambitious as the Vision this report proposes, TBMCS is technically more advanced than any other Service program. It should capitalize on this position by 1) inviting the Navy and Marine Corps into the development, 2) embracing DISA's GCCS

Common Operating Environment with an offer to extend it to an object oriented system, and 3) partnering smartly with functional activities developed by other Services.

⇒ All AF C2 programs should he placed in the same Program office and under the same acquisition authority.

⇒ All weapon systems and weapons programs should fence specific program dollars for C2 integration tasks to be executed by the C2 acquisition authority. Tasks of this C2 program would include 1) "backlinking" all shooter platforms to C2 nodes, 2) data interoperability, and 3) engagement control applications (attack assessment, retasking/targeting, auto-routing) development.

⇒ As data becomes a factor in the missioncritical task (such as guiding weapons from off-board sensors and key "shoot-look-shoot" precision platform operations), this data will require the redundancy of a "fly-by-wire" flight control.

⇒ Reliability, maintability, and survivability needs must be taken seriously-programs must be structured properly and off-the-shelf equipment purchased accordingly.

⇒ Discovery is an essential element of the C2 development process; specifically, the process should investigate emerging technologies. Today, this would include increasingly internet-like systems with browsers and viewers, developed on an object oriented system and enabled with JAVA agents, Two years ago, none of these elements existed. For a C2 system to maintain relevance and to some degree be "future proof," it must have an adaptive capability to absorb and leverage the unknown. The Air Force should engage in an iterative process of C2 systems discovery and development.

⇒ The planned C2 Battle Lab should be actively engaged to develop an ACTD-like approach, modeled after the "JFACC After Next" ACTD proposed in the following section of this chapter.

⇒ Specifically, a memorandum of understanding between ACC and DARPA could be expanded to include operational concept development, exploration of split-AGC and "reachback" concept as well as lead to potentially more effective operations, especially in prosecuting "short dwell targets," the present focus of the work.

⇒ Attention will be needed to harmonize the DARPA effort with the TBMCS program. Some of the applications and services presently envisioned by the DARPA work overlap with planned improvements in TBMCS. Also, the object oriented architecture of the DARPA-sponsored GCCS Leading Edge Services (LES) are duplicative and are not coordinated with the GCCS program office, despite the adoption of the GCCS name.

4.4.2.3 Logistics, Sustainment, and Mobility. While this discussion has focused on the mainstream C2 mission, it is clear that mission execution is inextricably tied to the logistic, combat support, and Global Reach mobility resources. Furthermore, it is imperative that the command and control regime include those considerations for synchronizing the support infrastructure with the overall battle planning and execution cycle.

Despite the philosophically appealing construct that there are no fundamental barriers to applying a unified C2 doctrine and support system across a broad range of functional mission areas (e.g., operations, personnel, maintenance, supply, finance, civil engineering), the Air Force is not on a path toward that vision. There are many reasons, most historical, for this state of affairs, By and large, the early applications of communications and data automation techniques were developed for inventory tracking, accounting, and engineering calculation. Application of automation was limited by available technology. Within the constraints of what could be done, as seen by managers charged with mission accomplishment, an episodic target of opportunity, rather than systematic approach to automation, was the natural schema. Automation enabled scaling of such things as inventory control and therefore became a critical technology. The track record for migration of these individual systems to an enterprise support environment is at best muddled. Despite clear-cut advantages to both vertical (e.g., highest to lowest echelon of the organization) and horizontal (e.g., cross functional) integration, a satisfactory harmonizing architecture has not been adopted.

- Recommendations. There is a critical need for immediate and deliberate actions toward a single information processing (with underlying communications) architecture for information systems for both command and control and combat support direction.

  ⇒ Increase the effectiveness of reduced force structures by minimizing shooter "turn around time" by carefully orchestrating repair and replenishment activities.

  ⇒ Base support actions, managed by systems such as AF GCCS (formerly BLSM) and IMS, should be tightly integrated with the tasking systems of the air operation (TBMCS).

  ⇒ The Defense Information Infrastructure (DII) defines a Common Operating Environment (COE) that should be leveraged to achieve the goal of a defense-wide network for information sharing, collaborative planning, synchronized combat execution, and efficient sustainment.

  ⇒ At the same time, the SAB strongly recommends that the DII COE evolve towards an object oriented software environment that can provide the basis for technical migration of legacy systems' capability into a single future architecture.

  ⇒ The need to link processes among the traditionally "stovepiped" automation users and applications quickly subsumes the impact and turbulence of immediate migration.

  ⇒ Moreover, there is a need to extract the critical information elements that current automation systems operate against-the main effort should be to standardize the essential/critical information. Many data elements (especially coalition and legacy system data) will never be "standardized."

  ⇒ Better means of "understanding" and incorporating disparate data to relevant decision systems need to be developed. This includes means of self-describing data and the use of fuzzy data so that common perspectives of the battlespace and combat support can be established.

4.4.2.4 Airborne and Space-Based Operations.

4.4.2.4.1 Airborne Operations. Manned airborne platforms place humans at risk, are expensive to maintain, and are more costly to upgrade. Removing personnel from these platforms will free up platform space for enhanced sensing operations. The platforms considered include ABCCC, AWACS, JSTARS, and Rivet Joint. Some of these platforms can be retired almost immediately and some within the next five to ten years. On the other hand, delays in implementing decisions do not necessarily reduce the effectiveness of the recommendations, although these delays may decrease the potential cost savings or incur additional sunken costs which will not be recovered.

- Recommendation-Retire ABCCC. The SAB recommends an ACTD to demonstrate that ABCCC functionality can be accomplished by a UAV-relayed communications link to a C2 platform on the ground. Initially, this can be done using the ABCCC module at a ground station. The follow-on system could be built into a ground station or in a modular fashion to allow the functions to be performed at the AOC/CRC/ROCC/SOCC. After executing a successful ACTD, the Air Force would no longer require ABCCC.

  - Steps.

  ⇒ The first step would be to transition from airborne ABCCC capsule to ground base ABCCC capsule linked to a UAV communications relay.

  ⇒ The natural progression would then be to accomplish the communications relay via a satellite.

  ⇒ In parallel with the migration from manned to unmanned platform for the communications relay, the location of the C2 element itself must be considered. As mentioned above, the first logical step is to use the existing ABCCC C2 capsule at a ground location, linked back through the UAV relay via COMSAT relay.

  ⇒ The next transition is from the physically constrained ABCCC capsule to a regional C2 cell in the Air Operations Center.

  ⇒ The final step is to migrate to a split AOC operation. This extends the C2/C3 range and allows the commander to direct, react, and coordinate.

  ⇒ Future scenarios could include a virtual Combined Air Operations Center (CAOC) at a fixed location. This cell would provide real-time beddown for fast-breaking operations and allow the Joint Forces Commander and the Airborne Component Command to determine whether and to what extent to move C2 activities forward into an area of responsibility.

  ⇒ The results from the ACTD would be sufficient evidence to terminate the ABCCC upgrades and eventually the entire program,

- Recommendation-Ret Rivet Joint RC-135. The RC-135/RJ and Combat Sent platforms collect and exploit unique communications intelligence (COMINT) and electronic intelligence (ELINT) and provide the information to the warfighters. Current remoting technology allows the back-end crew to be situated at a ground station in CONUS, at a Regional SIGINT Operations Center, or in the area of responsibility where crew members can tune the receivers and analyze/exploit the collected information prior to forwarding the information to the warfighters. This entire process can be done via UAV and space technology/satellite relay.

  - Steps.

  ⇒ Remote the back-end crew to a ground station. Doing so would allow an expansion of the sensor suite on the airframe or, using miniaturization, migration of the sensor suite to a UAV.

⇒ The next step would be to transition some sensors to space. This includes threat data as well as other types of information, such as meteorological data.

⇒ The Rivet Joint ACTD will demonstrate that the capabilities can be done as well or better at a ground station with remoted capabilities.

⇒ Using the ACTD results, terminate the Rivet Joint program

⇒ It is anticipated that the retirement of the Rivet Joint fleet can be done over an eight-year period, with the COBRA BALL aircraft the last to be retired. This retirement schedule should be based upon retiring three aircraft per year.

⇒ The SAB therefore recommends that recent authorizations and appropriation for procurement of two additional Rivet Joint aircraft be transferred to support the acquisition of Link 16 equipment for ground stations mentioned above and upgrade of other ground- and air-based platforms.

⇒ The SAB also recommends the funding requested for new CFM-56 engines for the Rivet Joint aircraft be transferred to the AWACS line to allow a faster engine retrofit of that fleet.

- Recommendation-JSTARS. Using the same arguments, it is easy to see that the JSTARS functionality can be migrated as well.

  - Steps.

⇒ Remote the back-end crew to a ground station. This would enable either an expansion of the sensor on the airframe or, using miniaturization, a transition of the sensor to a UAV.

⇒ A natural migration scenario would be to transition the sensor to space.

- Recommendation-AWACS. After migrating away from manned ABCCC, Rivet Joint, and JSTARS platforms, AWACS is the next logical candidate for remoting the back-end operations. Other things to consider: back-end crew to ground? [remote radar video—LOS/Beyond LOS (BLOS)], sensor upgrades?; C3 to UAV or space?; sensor to UAV (bi-static radar)?; sensor to space?

  - Steps.

⇒ Remote the crew to a ground station. This would allow expansion of the sensor suite on the AWACS platform, particularly for improved performance against low observable (LO) air targets.

⇒ Continue to study the feasibility of providing an improved sensor system on an unmanned platform and in space.

- Recommendation-JSTARS and AWACS Sensors. The sensors for monitoring and tracking stationary and moving ground targets require much less power-aperture than those for air breathing targets. This determination was based upon speed, maneuver, and LO technology requirements as applied to the ground and air.

- Steps.

⇒ Although JSTARS is the newest airborne platform, it is technologically feasible to transfer the sensor capabilities and voice communications to UAVs while crew members can be off-loaded to the Ah Operations Center, Control and Reporting Center or Element, or the Regional Operations Control Center or Sector Center positions back in the United States.

⇒ Plans should be made to move as much of the JSTARS mission to space before 2025. AWACS has a plan to off-load crewmembers in the 2005 timeframe. In addition, an AWACS follow-on system is anticipated in approximately 2025. Of course, technology should be revisited based upon budget constraints and evaluation of space-based and LJAV technologies.

⇒ The employment of UAVs as an interim step to space for the JSTARS mission is logical. This step could serve as a cost mitigation effort and operational concept development opportunity that could provide detailed understanding of how to effectively employ the multi-faceted, multi-phenomenology perspective possible from space against the variety of missions possible.

⇒ In addition to the above, sensor radar technology development for the JSTARS mission must be addressed at the laboratory level. Evaluation of current technology shows little work being done in sensor upgrades. S&T funds should be earmarked immediately to advance this key capability to meet future needs and aid in moving this capability to space.

4.4.2.4.2 Space-Based Platforms. The current sensors cannot be migrated to space; however, with technology developments on sensor upgrades, the SAB believes that the size of the sensor can be decreased while upgrading the capabilities. A logical progression for the smaller, improved sensors would be to deploy them to space. The timeframe for this would not be within the next 10 to 15 years. Previous sensor studies have documented the technical and financial challenges of the move from air breathing platforms to space-based wide area surveillance architectures. The validity of these studies is not questioned for the case of traditional, monostatic surveillance radars. There are several technology areas such as space power generation and storage and radiation hardened electronics and power systems that drive the practicality of space-based surveillance systems. The challenge of long lived, high power, low earth orbiting systems is beyond current technology and affordability.

- Recommendation. The SAB encourages prudent investment in these key technologies such that the necessary capabilities will be in place to compare space options with air breathing JSTARS and AWACS alternatives. The public sector's ah traffic control systems appear to be postured to embrace cooperative position reporting (e.g.; cooperative surveillance) as a replacement for air surveillance radars. This poses a potential air defense problem in that the majority of air defense surveillance radar data is generated by the Joint Surveillance System. In the event the civil sector elects to abandon this surveillance mission, the need to field an air defense surveillance system against those enemies who may not cooperatively identify themselves might well tip the balance of economics in favor of a space-based radar surveillance system in advance of a follow-on AWACS decision. This potential need underscores the importance of technology investment towards an eventual space-based, worldwide, wide area, all weather surveillance capability.

4.4.3 Advanced Concept Technology Demonstrations (ACTDs). The Air Force should establish and/or support the following ACTDs. These ACTDs act as risk reduction first steps toward longer term, programmatic changes and ultimately achieving the C2 vision. Each of the ACTDs will require a moderate capital investment.

- SPEAKEASY ACTD. **Exploit** the software programmable waveform technology developed in the Joint-sponsored (Air Force, Army, DARPA) SPEAKEASY program to develop an ACTD that explores both ground-based and airborne operational concepts while simultaneously reducing risk for full-scale production. Begin a concerted antenna technology program to fully exploit, in the later stages of the ACTD, the full spectrum opened by the programmable technology. Explore the operational concepts of using an integrated communications capability in ground, airborne, and man-pack systems.

  ⇒ The first application of this technology should be in ground-based systems. The operational objective is to increase the mobility and flexibility of the ground TACS system, while reducing risk for its application in airborne systems. The program should continue Link 16 development and begin flight certification and integration testing for airborne use-both at an accelerated pace.

  ⇒ The second phase is the potential high payoff part of the program. This phase of the program should support concept development on airborne systems-both manned and unmanned. Data link concepts on manned aircraft should be explored using Air National Guard F-16 test assets, in both air-to-air and air-to-surface operations using the programmable capability to cut across disparate data systems of Army, Navy, Marine, and Air Force systems. The UAV portion of this phase should develop a communications payload for the Operations Information Support ACTD, with the objective of extending information support capabilities across a theater battlespace and extending the global connectivity of Air Force long-range strike operations. This portion of the ACTD would demonstrate in a "fly before you buy" sense the concepts and systems capabilities required to make many of the large-scale transitions.

  ⇒ The third phase of this program should exploit EW, IFF, EIFF, navigation, commercial (RF/SATCOM), and other waveforms. This phase should continue development of the computational and "in the box" networking capabilities of the technology to meet advanced operational concepts with potential injection into the Integrated Modular Avionics (IMA) program. Example waveforms along with proposed functionality objectives are listed below:

Waveform	Operational Objective
UHF AM Have Quick UHFDAMA Link 16	Minimum functionality for deep strike demonstrations and Global Hawk communications payload
VHF FM	Desirable for CAS and Army/Marine ground support
SINCGARS **Milstar MDR** CDL	Mid-term growth for increased robustness, Milstar augmentation and sensor support

- Global Hawk ACTD. The Global Hawk ACTD examines cross-domain operational concepts between air, space, and surface operations and extends the global connectivity of Air Force assets. Using technology from the Tier 2+, Global Hawk program, and SPEAKEASY programmable waveform ACTD, it will explore operational uses of adaptive communications links between remoted C2 sensors and shooters operating within the battlespace. It will also supplement existing, overtasked MILSATCOM assets by providing an intra-theater, pseudo-satellite capability. Furthermore this ACTD is a risk reduction approach to potential programmatic changes in the ABCCC and other airborne operations. In this phase, the ACTD will remote the ABCCC command capsule and radio relay functions in an attempt to provide a more scaleable ABCCC operation as well as more robust, survivable m-theater communications. In addition to the waveforms developed under the SPEAKEASY ACTD, this program will exploit Milstar and SCDL (Surveillance and Control Data Link) survivable waveforms.

- <u>ACC "After Next" ACTD.</u> The JFACC After Next ACTD (presently funded by DARPA at over $100M) should be embraced and expanded to complement the Air Force's Theater Battle Management Core Systems (TBMCS) program.

  ⇒ Objectives of this program should 1) advance the operational concepts involving "Reachback," supporting and reducing theater-deployed "footprint," 2) enhance decision support tools that enable dynamic force control and reallocation-both in projecting the battlespace decision environment to executing battlefield forces, and 3) integrate modeling and simulation tools (to include software code interoperability and reuse.) to facilitate operational decision making, mission rehearsal, and training, as well as investment support.

  ⇒ Key technical elements of this ACTD would be to facilitate TBMCS migration to a robust GCCS common operating environment and to develop data and track correlations to provide a consistent information "backplane."

  ⇒ Essential activities of this ACTD would be to establish a lead point of contact for the work.

  ⇒ Provide Air Force R&D and operations and maintenance (O&M) money to complement the DARPA funds in fusing TBMCS and JFACC efforts as one.

  ⇒ Program acquisition dollars to "catch" the technologies. Actively engage the JSIMS and NASM modeling projects and DMSO to produce a Modular Reconfigurable C2 Interface (MRCI) and to establish a process to share software code development methodologies and reuse.

- <u>Global Data ACTD</u> There are many, many sensors collecting data on various aspects of the battlespace, including AWACS, JSTARS, RJ, U-2, National systems, on-board sensors, and environmental systems. Using robust connectivity, all the information should be stored in a global data warehouse. Currently, information is "stove-piped" in many ways; collected for a certain user, processed, and forwarded to the user. Any leftover pieces of information are discarded. In the global data warehouse, the information would be catalogued and available to all users, including correlators, modeling and simulation applications, applettes, and others. The global data warehouse does not necessarily have to be centrally located; it may he electronically co-located. The Global Data ACTD would

  ⇒ consider a single, logical "data base"-an information construct or a "one stop shop"-that receives, stores, and makes accessible all data collected by the many sensors.

  ⇒ enable the "common feed" applications programs that generate a personalized view of sensors, mission plans, target folders, and support activities.

⇒ maintain linkage to National systems data. The ACTD would span the levels of control from force and mission to the engagement.

⇒ develop common data models for "critical" shared information; adaptive, self-defining data schema for incorporating future and legacy data; data "agents" and "cyber cops" to ensure data pedigree. The ACTD would include data models and data dictionaries, logistics and sustainability, and sensor data.

⇒ leverage the Battlefield Awareness Data Dissemination (BADD) ACTD networking and computing architecture, be compliant with the GCCS/Leading Edge Services (LES) common operating environment, and fully exploit the Defense Information Infrastructure and distribution pipes like DISN, GBS, MILSATCOM, and theater communications networks.

- Rivet Joint "Back-End" ACTD. Remote the "mission tube" of a large platform.

⇒ Using current technology, remote all the "'back end" functions of Rivet Joint to a Regional Signals Intelligence (SIGINT) Operations Center.

⇒ Objective would be a risk reduction activity for developing the Global Hawk SIGINT mission and eventual migration to space.

⇒ This ACTD would preserve the selected (and possibly upgraded-longer mission time and payload) Rivet Joint for the more focused collection missions.

⇒ Using a CDL-lie data link, the ACTD would remote both the operator positions and the data they collect to a ground station.

⇒ The leave-behind capability would be a Rivet Joint that is more operationally flexible and scaleable.

⇒ This ACTD would provide the logical tactical SIGINT collection mission progression from manned platforms to UAVs and space.

⇒ This would be the proof of concept for remote manning of other large, multi-role C2 platforms and would reduce the cost of other Service programs such as the EP-3.

- Multiple-Media Network Strategies ACTD. As discussed earlier, the path towards a global grid of communications providing seamless connections among every battlespace actor is extremely complex. The communications systems of systems includes a variety of media ranging from radio communications in the ELF, VLF, LF, HF, VHF, UHF, SHF, and EHF spectrum to copper and optical communications. A wide variety of techniques are used to impart information on these carriers. Each spectral segment and modulation technique has attendant bandwidth, interference, and disruption mechanisms that manifest themselves in a wide range of performance characteristics. In general, bandwidth can be traded for low bit error rate or high availability or equipment simplicity. Moreover, different kinds of information systems require different levels of performance from their communications links. Analog voice, for example, is highly tolerant of errors and interference, while certain digital techniques become ineffective at high bit error rates. Operating environments limit applicability of some technologies. Submarines operating below periscope depth have extremely limited communications capabilities since water impedes the propagation of all but the longest (e.g.; ELF) and shortest (e.g.; highly energetic particles such as neutrinos) wavelengths of energy.

⇒ This goal of this ACTD is a better understanding of how to exploit the wide variety of communications capabilities available in the battlespace, as well as to avoid or mitigate an enemy's ability to exploit shortfalls.

⇒ The concept is a continuing blue team and red team exercise, the purpose of which is to assess how to route and alternatively route data over a variety of communications media—how to plan restoral operations and networking schemes, how to shed users or reduce their use during stress periods. and how to build the necessary plans and responses to attack for graceful degradation of communications services and rapid restoral.

⇒ A team of government specialists, commercial carriers, and contract advisors will exercise, then improve, a multi-media network, developing a long-term strategy for the global grid.

⇒ The widest range of communications services, both government and commercial, should be made available for this exploration. Forward error correction, network management hierarchy, data protocols, technical control, performance surveillance, quick reaction, and load shedding should all be considerations for this "build a little, test a little" ACTD.

4.5 Conclusion

To address the Vision of the future, the Air Force should focus migration plans with the following concepts in mind:

- Put people at the point of interaction with the information. not on platforms. Thc Air Force should have no personnel on surveillance, SEAD, and reconnaissance platforms and should reduce presence on strike and air defense systems by 2025.

- Invest in a robust communications infrastructure. These investments should include the transport medium, terminal equipment, and the protocols and waveforms that ride on them. Prudent use of UAV and space systems (military and commercial) would include working operational concepts in parallel with the technologies being developed.

- Divest piecemeal avionics systems The Ah Force should procure multi-capable, integrated systems. These systems include avionics for UAV and space payload operations. A JAST-like program office should be considered for integrated avionics architecture and development.

- Integrate data and reduce dependency on voice-based systems. Divest "message" and reduce dependency on voice-based systems. Move to integrated data systems.

- Develop decision support software and simulator& Develop mission tailorable and adaptive decision support software and simulations.

- Reduce workload and facilitate knowledge. Invest in elegant human interfaces that reduce workload and facilitate knowledge building.

- Influence standards in a nartnershio with industry. Become an influential player in the developing commercial and international standards processes.

Chapter 5

Process

5.1 Introduction

This chapter provides a description of the process the Air Force needs to institutionalize to assure it can rapidly exploit technology advances and continue to modernize its C2 systems. The process begins by identifying the problems with and limitations of the current corporate process for defining and implementing C2 and derives from those problems the requirements that corporate C2 process must meet in order to successfully implement and sustain the C2 vision. The process then proposes an approach to implementing those changes and closes by recommending the initial actions the Air Force should take toward institutionalizing this new approach to defining, developing, acquiring, fielding, sustaining, and operating its C2 system. The scope of the evaluation addressed the current state and processes used to formulate and implement C2 policy; doctrine; requirements; Planning, Programming, and Budgeting System (PPBS); technology; acquisition; education and training; and organization. With the exception of policy, recommendations are provided for changing the Air Force's implementation of these processes.

5.2 C2 Modernization Process Problems

The most obvious symptom of the problem is that the C2 support system is reinvented every time a new operation is engaged: Desert Storm and Bosnia both illustrate this point. While tailoring C2 to the unique requirements of an operation is a necessity, most of the effort is spent re-engineering how the collection of C2 tools are connected and integrated, trying to achieve an acceptable degree of interoperability. Since the resulting configuration and operational workarounds are unique, C2 training is inadequate. The result is an unacceptably long time to achieve an operational capability in theater and difficulty in sustaining an efficient C2 operation with trained personnel. Without an integrated C2 system, a limited capability exists to allow an assessment of the value a new capability will bring to an operation. Consequently, the Air Force finds itself with an almost infinite list of "could do's" with limited means for determining what it "should do." This decisionmaking paralysis at the requirements level, combined with funding and acquisition inefficiencies, makes the timely insertion and fielding of new C2 capabilities the exception rather than the rule.

Perhaps the most significant obstacle to supporting the JFACC with a tailorable, interoperable C2 system is rooted in an approach to equipping and provisioning for C2. Interoperability problems are often blamed on stovepiped acquisition. But stovepiping of C2 systems begins much earlier than acquisition or operations. Systems are stovepiped from the very beginning in terms of how they are defined, funded, advocated, and managed by the Air Force. This stovepiping problem extends to the very core of how forces are equipped.

Figure 5-1 depicts this situation with several current C2 systems as examples. Requirements are defined by users in different commands, in different field operating agencies, and in different parts of the Air Force. Funding to develop the systems that answer the requirement is derived from independent financial processes which in many cases aren't integrated until they reach the Air Force Board. The development and acquisition of individual capabilities usually is accomplished through one or more parts of the PEO/DAC structure. Sometimes, a capability is acquired from outside the normal acquisition structure. Development is done in different commands and in different development centers with the common result that stovepiped systems with limited interoperability are fielded.

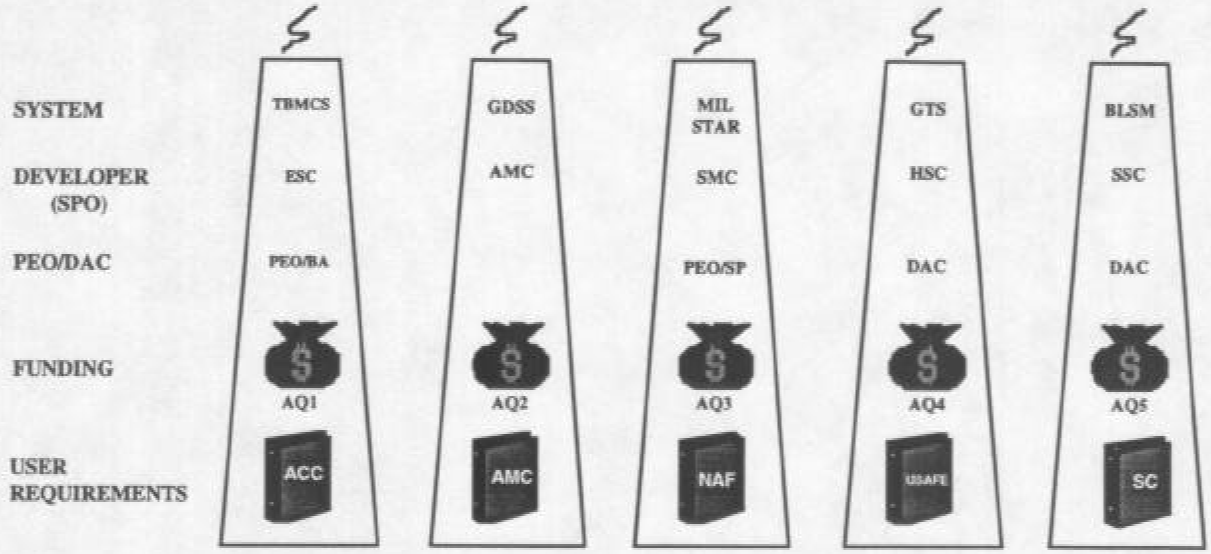


Figure 5-1. Air Force C2 Evolution

5.3 A New C2 Modernization Process

From the discussion of the problem, the fundamental requirements for the C2 process the Air Force must implement to successfully support the JFACC's C2 needs are extracted. There are six principal needs that the corporate process must fulfill to successfully implement and, perhaps more importantly, sustain the C2 Vision.

- Consolidate and integrate mission needs for conducting C2 in a joint and coalition environment. C2 needs cut across all MAJCOMs. The Air Force must integrate the common and unique C2 needs of each mission, establish and maintain an overarching C2 vision and investment strategy, and continually evolve the C2 requirements as new needs or opportunities present themselves, without getting caught up in a lengthy validation process.

- Focus the corporate PPBS structure on advocating and managing an integrated C2 program. Financial planning must be integrated in the same manner that the requirements process is integrated. This allows more effective investment decisions within the integrated C2 system and allows the Air Force Board structure to make decisions about the overall capabilities of the C2 system, rather than trying to decide to invest in a new planning tool vice an upgraded communications link.

- Develop a methodology and tools to determine the value of new capabilities. The linchpin to making integrated and evolutionary requirements and funding processes work is to establish a methodology and toolset that determines the operational utility and cost effectiveness of new capabilities.

- Be able to rapidly select, mature, and field new C2 capabilities. The process must expeditiously select concepts and capabilities which best meet mission needs, and rapidly mature, integrate, and field those new capabilities in an operational system. Changes to operational concepts, Training and Transfer Plans (TTPs) must be accomplished in parallel with the development, making an operational proving ground an essential element of the process.

- Organize, train, equip, and nrovide for common C2 across the Air Force A common framework for C2 across the Air Force allows tailoring the C2 support system to the needs of the mission without developing new processes, systems, or training. Numbered Air Forces should have full time units dedicated to operation, support, and continual evolution of the C2 system. A major responsibility of these units will be to participate in the development of new C2 capabilities by conducting operational evaluations, CONOPs, procedures, and training development.

- Continuallv evaluate and evolve C2 doctrine and operational concepts. With the rapid advance of technology in this area, doctrine will, in general, lag behind the opportunities that new capabilities make possible. As the C2 system evolves, the Air Force must continually look for new opportunities by evaluating C2 doctrine and testing new concepts.

5.4 A New C2 Modernization Process-An Enterprise Approach

A principal approach to organizational change used by industry is to create an "Enterprise Area" to focus management and resources on a specific problem or new businss arca. The Enterprise approach defines C2 as a system and uses this as a unifying theme to manage and integrate C2 across the organization. The Enterprise has two basic thrusts. First, bring defining and sustaining C2 vision up to a corporate Air Force level, integrating C2 strategic planning, requirements, and financial planning across all mission areas. Second, implement an evolutionary process which not only allows rapid technology insertion but drives the evolution of doctrine and requirements to make maximum operational use of new opportunities.

Them are several guiding precepts that the Enterprise must implement in order to be successful.

- Board of Directors. The Enterprise requires a board of directors (BoD) charged with focusing and managing C2 for the Air Force. A General Officer Steering Group (GOSG) would provide the right level of senior leadership involvement. The BoD should be chaired at a level where C2 needs and investment resources come together.

- Evolutionarv Approach. The Air Force already has a substantial investment in C2 systems which have great utility. The sunken cost is too great to consider wholesale replacement, so migration of legacy hardware and software becomes a key element of the process. The Air Force should adopt an overall concept similar to the commercial industry model of evolutionary development. The key features of this model are: continuous capital reinvestment in the system, continual evolution of the elements and products of the system, and continuous user involvement in assessing and shaping the system.

- Managed Chaos. The process must be structured to "manage chaos." An innovative and competitive environment should be encouraged in which ideas will vie for implementation into the final system, and in the end there will develop a natural selection process that will lead to the best overall capability. All players in the Air Force, DoD, and industry must have the opportunity to illustrate and demonstrate ideas that could enhance C2 capabilities. Some discipline must be imposed, but it should not be so throttling that the discipline inhibits people from coming forward with ideas and thoughts for new capabilities.

- Technoloev Push and Requirements Pull. Advances to the C2 system should be based both on technology push from commercial industry and requirements pull from users. The process must continually evaluate technologies emerging in the commercial world and quickly and efficiently insert capabilities with operational or cost benefits for C2. Getting ideas from industry to users for evaluation will stimulate ideas for new ways to solve operational problems using both new and old capabilities.

- Streamlining. The process must cut both the time and cost of getting a new capability to the field. For incremental upgrades the process should be able to reduce solicitation and contracting overhead, use the development process as the source selection process, allow requirements and product development to proceed in parallel, conduct early operational evaluations in parallel with product development and test. embed training in the system, and require "backward compatibility" to reduce integration and training.

- Partner with Industry. To couple tightly to the revolutionary ideas and products that come from the commercial world, the Air Force and DoD must build a partnership with industry which allows them to understand where product development is going. When circumstances permit, the Air Force should attempt to influence the commercial marketplace to include capabilities which support needs that otherwise would not have been met.

5.4.1 Establishing a Corporate Level Focus for C2. Establishing a corporate level focus for C2 requires changes in the Air Force's implementation of four major processes: strategic planning, requirements development and validation, financial planning, and technology management. The fundamental objective in this area is to break down the current stovepipes fragmenting C2 efforts and integrate C2 across the Air Force and its missions. Currently, the place where C2 comes together is at the Air Force Council.

- C2 Strategic Planning. The strategic plan provides a long-term view for C2. The plan needs to integrate all of the mission needs for C2 from the users' mission area plans (MAPs) and mission support plans (MSPs). The MAPs and MSPs must be created to take a broad view that ensures that the mission needs reflect what is going on in the Joint arena. The Vision must address plans for migrating existing capabilities and provide a long-term investment strategy. The DoD should control investment; it should provide seed money for going through the source selection and the competitive activities inherent in the use of the development engine; and then decide when a capability is ready for more mature development and fielding.

- C2 Requirements Integration. Requirements integration should be accomplished by developing a Capstone Requirements Document (CRD) for the C2 System (see Figure S-2). The CRD provides a top-level definition of the overarching requirements for C2 and a general architecture for the C2 System and establishes the foundation enabling vertical and horizontal integration of the C2 system.

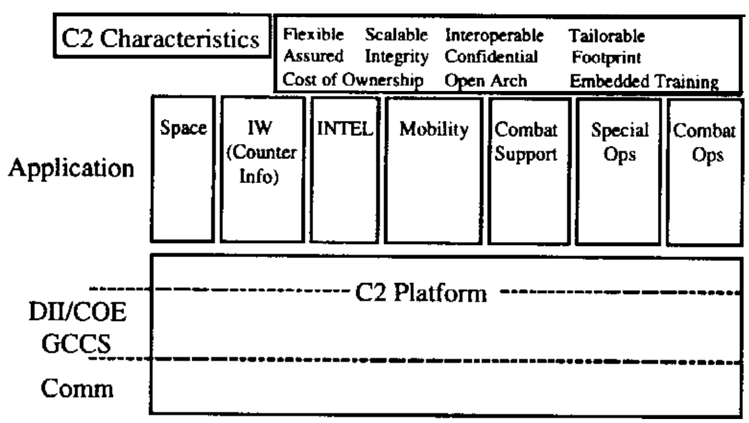


Figure 5-2. Capstone Requirements Document

The overarching C2 requirements provide a focus for top-level mission requirements. They arc stated in broad terms and essentially form a set of guidelines and characteristics under which the more specific requirements supporting each mission area and the C2 infrastructure can evolve under the guidance of the BoD without a lengthy revalidation of requirements when a new capability is being considered. Specifically, the requirements will include the C2 characteristics, needs, and tasks, how the integrity of the overall system is defined and maintained, how interfaces are defined, how interoperability is assured, and how security is to be handled. These overarching characteristics will provide measures of effectiveness (MOEs) and measures of performance (MOPs) which flow into the requirements for each of the mission areas.

A general system architecture was described in Chapter 3. This architecture separates data and common services from warfighter applications and provides a structure for each level: applications, data management, common services, and communications. The CRD captures this structure and defines top-level requirements for each mission area, defines the services which will be common for the system (both unique for airpower applications or drawn from those provided by GCCS), and defines joint standard interfaces and operating environments such as those defined by the GCCS common operating environment and the Defense Information Infrastructure standards and services, which will allow applications and platforms to "plug and play." Finally, the CRD is an integration tool which breaks down the requirements stovepipes and integrates the system in both a vertical and horizontal manner by defining the data flows both within and across mission areas. It provides not only the Air Force, but the Joint and DoD community with a definition, architecture, and interface standards for aerospace C2 systems.

- Financial Planning. The last of the stovepipes to beak down is in financial planning, specifically the process for supporting the PPBS resource allocation process. First. C2 system projects should be integrated and grouped to provide meaningful warfighting capabilities which compete against other warfighting investment proposals, rather than individual components of the system competing independently, often against other system components. Second, the DoD, as the advocate for C2, needs to have an understanding of how all the finances available for developing, testing, maintaining, sustaining, and upgrading C2 assets are being spent. Integrating resource planning across all appropriations (RDT&E, Procurement, O&M, and DBOF) and all C2 programs provides the ability to focus resources on the most urgent C2 needs of the JFACC. A necessary first step would be to create a single C2 Resource Management Panel. At a minimum, the C4 and Information Dominance Panels that currently exist in support of the AF corporate structure should be merged. This C2 Resource Management Panel will support the C2 BoD in creating and managing financial plans.

  An important part of this financial planning process is delegation of responsibility advocating C2 programs. The CRD provides a framework for that process. The MAJCOM or Field Operating Agency (FOA) that is responsible for a particular mission area will advocate the application capabilities required to support their assigned mission or functional areas. The common services and infrastructure which support everyone should be advocated at the Air Staff/BoD level since the requirements cut across mission areas and support more than one user. As the system evolves, the program and PE structure may evolve to emulate the CRD organizational framework.

- Technology Planning and Management. Technology management has several unique aspects for C2. Since commercial technologies are critical to C2 systems, the focus should be on understanding commercial R&D and products to sufficient detail that DoD can influence their capabilities to better match the needs. Cooperative development could take many forms, such as participation in standards committees, early product review (alpha/beta test sites), or providing seed money for specific issues, but fundamentally it has to be in cooperation as a follower of the development rather than as the leader. The technology management areas must also define and pursue niches that commercial or other DoD R&D will not address (e.g., secure long-range communications). Identifying, focusing, and leveraging R&D activities at DARPA, AF, and DoD Labs in these niche areas must be integrated with the overall strategic planning, requirements, and financial planning efforts.

To implement these recommendations, the current TBM Technical Planning Integrated Product Team (TPIPT) should be expanded and chartered to manage and implement the technology oversight functions under the guidance of the BoD. This group would recommend to the BoD the investments which the Air Force should make in order to influence commercial products.

5.4.2 C2 Enterprise—Institutionalize an Evolutionary Process

- Process Description. The process envisioned is a spiral evolution which continually assesses new technologies and needs as they are identified, matures and selects capabilities with operational benefit, and provides a mature capability to the C2 system for incorporation into the fielded systems. The process must encourage ideas from all sources: industry, users, and developers. An idea should be reviewed to confirm its relevance to the C2 problem and developed until there's a clear basis for determining the value that idea may provide. Occasionally, a capability will be significant enough in cost that it must go into the strategic planning and resource allocation process for funding. The process must terminate those capabilities and ideas that are not progressing or have been overcome by better capabilities. Figure 5-3 depicts this evolutionary process.

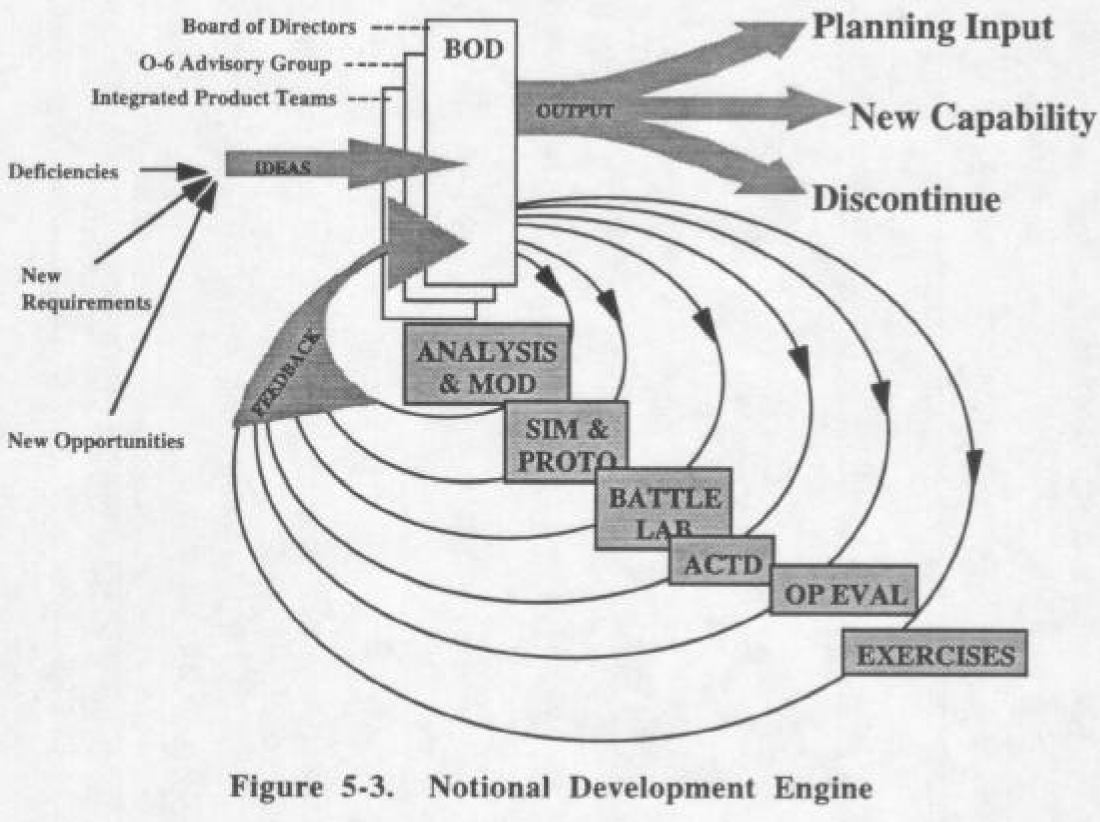


Figure 5-3. Notional Development Engine

The throttle for this process is the BoD and its supporting structures [Secretariat and Integrated Product Teams (IPTs)]. This Board structure determines the appropriate path and investment for new ideas input to the process. Each capability proceeds at its own pace and own path through the process, determined by its maturity, complexity, cost, and need. The capability may require all steps or only one, but each step builds upon the work of the previous. Critical to making this a timely and effective process will be delegation of authority to lower levels of the BoD structure. Thresholds for commitment of investment dollars should be established at O-6 and IPT levels.

It is clear that the BoD needs to be composed of general officers who represent the information interests of Air Staff and Air Force Major Comman ds. There are many issues that do not require high-level decisionmaking or attention. This BoD will be supported by an O-6 Advisory Group which in turn will be supported by IPTs and other subgroups that will carry the burden for implementing the development of new capabilities. The SAB strongly recommends that decisionmaking be. relegated as far down in the organization as possible in order that the bureaucracy does not slow down the process through which new capabilities are identified and fielded.

Let us discuss the development engine from a slightly different point of view than was used earlier. There is no question that the current acquisition process is cumbersome, slow, bureaucratic, and in many ways nonresponsive to both the needs of commanders and to the pace of technology. Fundamental to changing the acquisition process is the need for a streamlined way to insure that competition requirements are met while at the same time not having to go through multi-month or multi-year source selection processes. The development engine can be used as the fundamental source selection process.

New ideas, whether they represent responses to deficiencies or to new needs or opportunities that are based on technologies, can be funded for the purposes of exploration and maturation. Ideas will compete, and these ideas, many of which can come from industry, will then become a mechanism for identifying the capabilities and starting point to select the winners of the competition for a new capability. When the decision is made for a capability to be either put into the planning cycle or to move on to fielding, a down-select will have essentially been made to an industrial firm that has a product that is ready to be developed for fielding, having been tested and selected through a competitive process. In other words, the development engine can basically be viewed as having served as a vehicle for an open-ended request for proposals. Then, the selection process can be placed into a context that needs to be normalized as part of the Competition Contracting Act and the rules and regulations that govern acquisition.

In the view of the SAB, this should greatly expedite the process for getting new capabilities and for proceeding on with the development of systems in a context that both assures that the government's rights are protected and provides industrial organizations a fair opportunity to demonstrate that they have capabilities and can provide products that will be useful. The development engine in this phase then also provides a great deal of risk reduction and should lead to system development in which the issues are primarily those of maturing the process for the long-term and providing it for inclusion in the overall system in a timely manner. The SAB also believes the development engine then becomes a key tool in doing the value determination, It is often claimed, rightfully so, that it is very difficult to assess what value a new capability or a new product will bring to C2. In the context of the development engine this assessment should be greatly expedited and in the end will be a key determiner in the decisions of the BoD for continuing or not continuing a particular endeavor or activity.

At the center of Figure 5-3 is the BoD. This BoD has the job of managing the change process by making the decisions about the next step in a development and by assigning priorities to funding requests. Deficiencies come to this change board from any number of sources. There can be new requirements that are provided by individual elements of the operational commands. Systems may have deficiencies that need to be corrected, and proposed solutions to correct those deficiencies have to be evaluated. Finally, technology may offer new opportunities which have not yet been identified as a deficiency or a need.

The rapid growth of information technologies can and does easily outpace the appetite of users. The process must, therefore, accommodate technology pull as well as requirements push. All of these come together as sets of ideas, many of which would require small amounts of funding and some that may require substantial investment. There will be some ideas that are mature and others that are half-baked. The development path taken for a given idea can vary in accordance with any of these considerations. The Board structure decides the appropriate path and its associated investment. The intent of this discussion is to emphasize that ideas should come literally from all sources. Those sources, if the ideas have with them the finances and the resources to develop them to some extent, should require a minimum of scrutiny by the BoD. The change Board should review me idea and confirm that it indeed has relevance to the overall C2 capabilities that are sought but otherwise encourage the development of the idea until there's clear basis on which to identify the value that a given new capability may provide.

If a given idea should require analysis and modeling, this would be accomplished following the inner loop of the diagram. At some time, some relatively low-level part of the change Board, depending on the level of money that's involved. might decide that the analysis shows no value and the output would be to discontinue the entire activity. However, the BoD may say that it merits further exploration. The exploration can occur at different levels. There may be simulation and prototyping required to explore the concept, or there may be a decision to move a more mature concept to operational evaluation.

The tool that is envisioned as fundamental to the development engine and supportive of all types of operational evaluations and testing is referred to as the "Battle Lab." Ideas can come through sources outside of the Air Force such as the Advanced Concept Technology Demonstration (ACID). In ACTDs, user interest and involvement has been identified and a prototype may have already been developed. In these instances, the BoD may decide to provide Air Force funding and move to an operational evaluation using the Battle Lab. There may be other paths. The point that needs to be emphasized is that a particular concept or idea may take any of several possible development paths. A decision is made based on a determination of value that utilizes increasingly sophisticated and mature models and systems. The process should produce one of several possible decisions. The BoD can decide on further testing at any loop of the spiral. Or it may decide to discontinue the activity, field a new capability, or initiate a significant system development effort requiring substantial resources.

Figure 5-3 shows a flexible process which will allow the control of a given idea, wherever it comes from, in a way that will lead to the capability being integrated from the beginning into the system, when the decision is made to continue until the system is fielded. Some examples will be presented in a later section that illustrate how the process could be implemented for systems that currently exist and could go through significant modifications or upgrades.

- Process Functions. The development engine will provide the means through which all new system capabilities will be tested (see Figure 5-4). The development engine will itself provide the connectivity that supports the Air Force Intranet and will provide the means for browsing the Web. Through its support of multimedia communications and devices, the development engine will serve as the backbone for the way the Air Force communicates information. It provides the means through which various databases will be managed and the way information will be connected and stored and will define the standard data elements and the way one has to operate the system. It will be the basis for defining how the global C2 system will migrate and how the Air Force will remain in step with these DoD initiatives. It will enable the use of modeling in simulation in distributed fashion to support a variety of applications, not only the development process itself but the potential for supporting exercises in a variety of operational evaluations.

Given the development engine, and the fact that it must contain the infrastructure used by the operational C2 system, the engine itself then becomes the way to test the security of the system. Information security must be integral to the system. Red teams could be formed to attack the system and run their own tests to see how effective the system is at blocking intrusions and destructive interference.

The development engine also becomes the training and exercise platform. It provides a mechanism for defining interfaces so that industry, when it claims to have a new good idea, will have a base on which to demonstrate the utility of that idea The commercial world will not develop all of the technologies needed by the Air Force to accomplish C2, but it will develop a great many of them. The development engine will be the vehicle through which capabilities will be assessed and the performance of commercial products will be tested. Two results may come from this. One, the Air Force and the DoD may work with industry to change its products in some way, which enhances industry's position in the marketplace as well as satisfying DoD and Air Force needs. In addition, the engine may identify those niche areas in which the commercial world is not motivated to develop a capability, important though it may be to the Air Force. This then provides a basis for rationalizing the AF science and technology program in the area of C2. It provides a way to test new capabilities developed by the laboratories and puts into place the mechanism that will permit their maturation, leading ultimately to fielding.

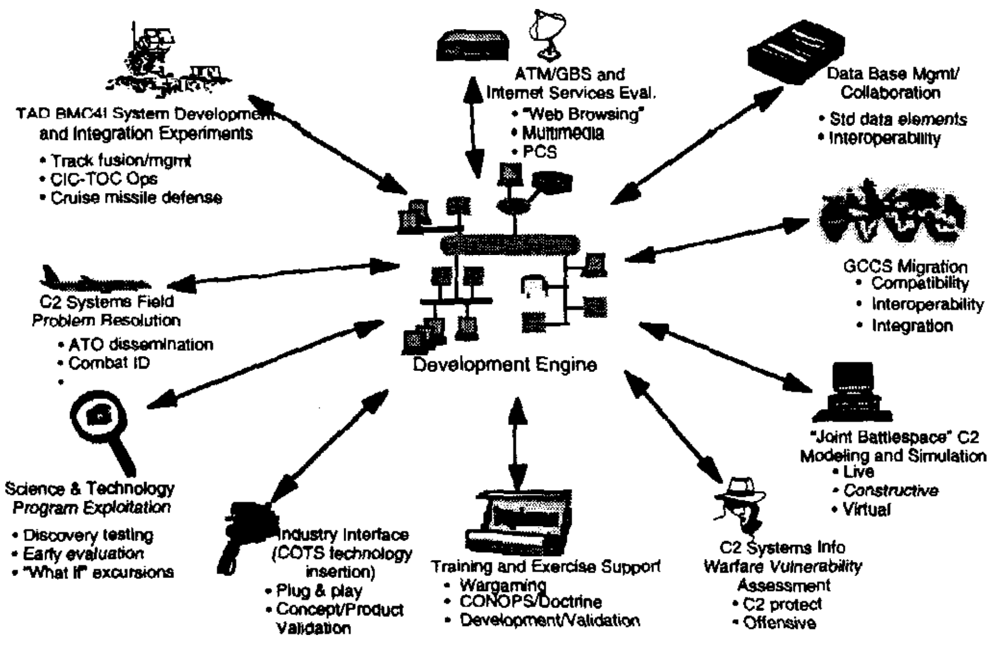


Figure 5-4. Development Engine Functions

The function of the development engine has other dimensions. When problems ate identified in the field, the development engine becomes the vehicle for assessing and working those problems and resolving them. It provides a mechanism, in addition, for developing the methods, the concept of operations, and possibly even doctrinal changes required to cope with new threats. The development engine provides the environment through which new threats can be addressed and postulated capabilities to solve the problem can be tested and evaluated. Ideally, this can be done before major investments have to be made that will lead to the fielding of the capability.

The development engine provides a basis through which the Air Force can provide a new methodology for source selection. In a sense, ideas can be tested on the engine. When different approaches to the same need are compared, a competition results in a natural selection among ideas. Tbis can then lead to the decision to develop a given capability. At that point, source selection may be as simple as down-selecting to the winner of the development engine competition. The development of the capability is a maturation that focuses on the characteristics for a fielded system. In other words, the concerns of sustainment, training, and modernization become the central emphasis of the development.

- Process Products. The development engine will require an investment. There is no way that this capability can be achieved without investing in the infrastructure that comprises the development engine or in the ways in which the development engine is used to achieve the functions that have been described. It will produce value assessments of C2 technologies and lead to the development of specific requirements for that capability that is based then on observed behaviors and performance coming from the development engine. The development engine will require an architecture that will be a product of the whole process. An investment is required to develop, maintain, and evolve the architecture. Finally, the development engine will produce the means to develop and evaluate changes to the concepts of operations and will provide support for training C2 operators.

5.4.3 Acquisition Streamlining. The development engine will provide a capability that enables the development of a variety of products. It provides an infrastructure for accomplishing the functions supporting the developments. In the final analysis, the integration of these products and the manner in which the development engine is used will determine the effectiveness of accomplishing tbe end-goals. Clearly, the development engine will be used in ways that will produce a mature capability. A key element of the use of the development engine is the role played by the BoD. It is the Board that validates requirements, determines the priorities for funding, and makes the assessment of when a capability is ready to go to the field. Individual capabilities, once they have been determined to be ready for fielding, will then have to be incorporated into the baseline system that will be used to conduct operations.

Doing this requires close interaction with the users. It is the users who will use this infrastructure to conduct operational evaluations and to develop their concepts of operations. Therefore, the integration of new applications developed for the user community becomes an absolutely fundamental role for the development engine. The applications, as they are developed as individual C2 programs, are matured and released for fielding after completing test on the development engine. The new capabilities are incorporated into the C2 system baseline. As part of the baseline, new training requirements would be included as part of the system description that accompanies the baseline release. The additional training would be only an increment to the existing training baseline that resides with the development engine itself.

Major changes to the way in which systems are currently acquired will have to be identified and built into the system if it is to be successful. One of the guiding precepts of the C2 Enterprise is to develop and acquire systems using best commercial practices. That involves continuous recapitalization and continuous product evolution and user involvement. Clearly, future C2 developments will involve the acquisition of COTS-based systems. There are approaches currently being developed that will facilitate the rapid purchase of COTS hardware and software. For example, the Command Center Product Line (CCPL) contracting initiative at the Electronic Systems Center (ESC) represents a radically different acquisition approach. Finally, it is imperative to use an object-oriented encapsulation process to deal with the problem of legacy software-the Common Object Requirement Broker Architecture (CORBA) offers the best approach to solving this problem.

The way systems are tested will change dramatically. The development engine provides the means during program development to test the system in an integrated environment. This should contribute greatly to the rapid maturation of new capabilities. It should, implemented properly, involve the user throughout the development process. Thus, test and evaluation begins very early and is done continuously using the development engine. Further, if training is included in the basic system design and training capabilities are provided as tools to support the specific application development, them will be minimal demands on the training tools required for a given application.

When the prototype architecture is defined and funding identified to capitalize the effort, it will be necessary to look at existing elements of the C2 system and decompose them into common services and support functions. Then the process can be started that will transition current legacy systems to this fully integrated system. Funding can be used for the systems that are identified for migration and to develop the elements that are to be included in the platform infrastructure and the development engine. The desired changes can be made, and these changes will then lead to a new version of the architecture. Analogous to the commercial world, this will lead to sequences of releases of both the architecture and the applications that are going to be included as part of the C2 system. The new architecture then could be used in the decision to recapitalize other elements of the system. The funding for all of these activities will be part of the recapitalization plan.

The continuing cycle of changes to the architecture, followed by changes to the development engine and the C2 system applications, will be accomplished on a schedule that depends on the results of "alpha and beta" testing of the modifications. This testing will occur continuously and will involve users of the system throughout. Changes will be incorporated into the C2 system baseline only after they have matured sufficiently to gain user acceptance. Then, a new version number will be assigned. This process mirrors the practices of the commercial information systems industry. It should be anticipated that there may never be a "final product." As with commercial software and hardware, the system will change as new needs are met or new technologies are exploited to improve performance or reduce the cost of ownership.

- C2 Product Lines. The timely insertion of COTS hardware and software products is an important consideration in the previous discussion. Currently, acquisition takes a very long time, driven in major part by the requirements attendant with the RFP and source selection process. The development process, as depicted earlier, then adds its own set of time constraints as a capability is fielded and integrated into the overall C2 system. A substantially different acquisition approach to the development of COTS-based C2 systems is being pursued at ESC at Hanscom Air Force Base, through the CCPL strategy.

  COTS hardware and software, requiring no substantial development, can provide most of the functionality required for any C2 center. To ensure that the COTS products can be integrated into a useful capability in a rapid manner, an architecture group defines the operational, system, and technical architecture that the command center system must satisfy. The architecture is developed in conjunction with system program offices (SPO's) and with industrial contractors.' The SPOs identify the requirements and the contractors define the capabilities of their COTS products. The architecture provides the overarching rules and standards by which COTS products will be included in an approved repository for use in meeting the needs of particular command centers.

The CCPL contracting strategy anticipates that contracts will be established with a number of different organizations. These organizations provide products that are stoned in a "reuse repository." Hardware and software elements will be made to be DII/COE-compliant in accordance with the standards put down by the architecture group. The basic concept is that as a needed capability is developed, the products that are used in the development will be taken from the "reuse repository" and assembled in a way that meets the needs of the application. The repository and the elements contained in the repository will change with time just as the technology changes, but always in line with the architectural standards that are defined by the architecture group. Presently, the CCPL approach is being applied to C2 computer systems, but plans are beginning to extend the concept to the acquisition of commercial communications, surveillance, and reconnaissance systems.

The CCPL approach allows the rapid purchase of the commercial hardware and software needed to build a command center. The source-selection and the contract award is done once and then each *new* development is accomplished within the context of the existing contract vehicles. This approach may provide a model for supporting the process that is proposed. The details of its implementation may have to change to fully meet the needs of this general process but nonetheless it appears to be a step in the right direction.

- <u>Isolation of Software Internals.</u> CORBA represents a major element of the proposed process as it enables the migration from legacy systems to the integrated C2 system that is envisioned. Figure 5-5 depicts the impact of using CORBA to evolve the Contingency Theater Automated Planning System (CTAPS). This planning system is a collection of a number of specific application programs which have been integrated together with a considerable amount of software. The system is cumbersome to work with and difficult to change but performs its function adequately. The structure does not lend itself to an evolution into the future.

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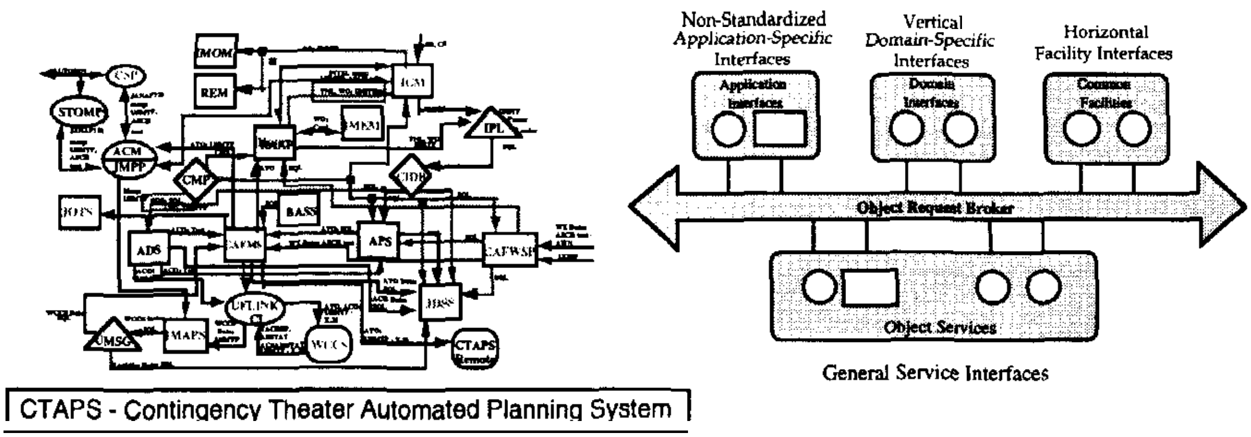


Figure 5-5. CORBA Encapsulation

CORBA can take the complex diagram that's shown for CTAPS and put it into a dramatically different mode. In particular, the object request broker becomes the common link that defines common interfaces for nonstandard, domain-specific applications for common services. The object request broker is itself built on various well-defined, very standardized, and well-specified object services which are available for each of the areas that are defined. CORBA provides, within the CTAPS context, ways to appropriately define interfaces among one or more of the application programs, putting them into a common context and allowing the evolution to a more modern system without changing any of the application programs that are implied in CTAPS.

5.4.4 Process Implementation. The overall process must support the functions listed. Supporting these functions requires specialized tools and dedicated resources. This infrastructure requires a toolset, engineering and integration support, and a demonstration facility. The core of the toolset is the Battle Lab, providing a platform and environment for modeling, simulations, testing, exercises, and training. The Battle Lab provides both a developmental and operational proving ground with the capability to emulate current and planned AF, joint, and coalition C2 structures. The infrastructure associated with this will lead to the requirement to develop a variety of tools, including C2 modeling tools and the Battle Lab. The Battle Lab will have to support a test and evaluation infrastructure with a variety of test environments, databases, and tools that allow a disciplined test process to be achieved and implemented. To do value determination and evaluate capabilities, there will have to be services and support functions that permit the use of models and simulations as well as exercises to provide necessary insights and determinations. The Air Force Battle Lab is depicted in Figure 5-6.

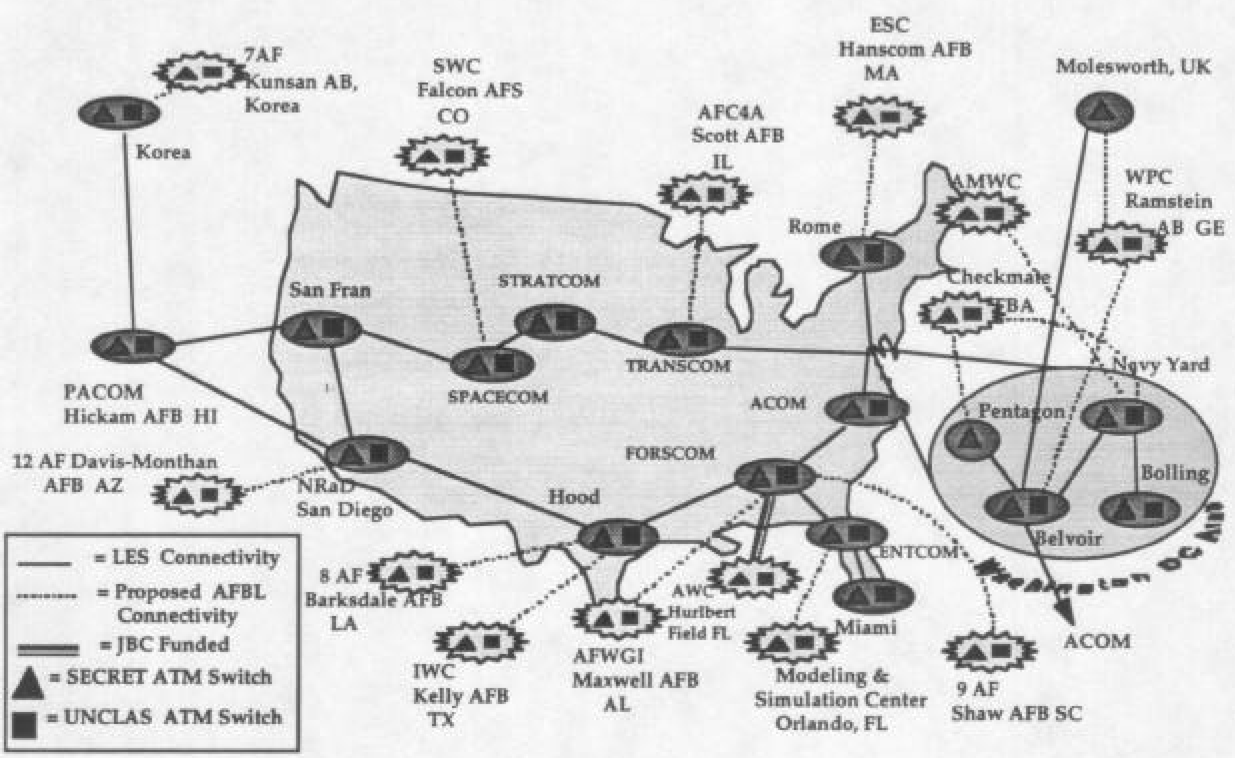


Figure 5-6. Distributed C2 Platform Development

The Air Force is part of the larger joint community, and this has to be accounted for in developing the engine through which system acquisition will be accomplished. The Air Force development engine must work in conjunction with the Joint Battle Center that is being developed by DoD. It must also be able to interact in a constructive and useful manner with other laboratory and command and control development activities. These include the Navy and Marine Corps

Warrior Labs, the Army laboratories, and the technical integration laboratories they have established. It has to be able to interact with the DoD Modeling and Simulation Laboratories. It has to be able to provide the wartighter support for joint demonstrations and exercises. It needs to link to various DoD integration and certification facilities such as the Joint Integrated Test Center at Fort Huachuca. And further, it has to work in a broad way with members of industry so that they can "plug and play" their proposed products with the rest of the systems. It is critically important that the Air Force development engine be integral to the overall development and test capabilities developed by the DoD.

- Svstem Engineering & Inteeration. The systems engineering and integration activity accomplishes the overall system design, establishes and maintains system architectures, conducts alternatives and cost analyses of new capabilities, ensures standards compliance, and tracks evolution of capabilities. This activity also functions as the coordinator/scheduler/test controller for development resource configurations and utilizations of the Battle Lab.

  There must be an investment in the systems engineering and integration activity that will enable this distributed, collaborative environment and capability to be developed. A Systems Integration Center (SIC) is needed that can provide the planning and development of the development engine itself. The design and implementation of the development engine and its supporting capabilities for the functions and the products that are to be achieved by it will require a major effort in systems architecture, engineering, and integration. Architectural elements ranging from the operational through the systems to the technical architectures have to be worked. The development of the common operating environment or basic infrastructure has to be dealt with and common data elements need to be identified. Open systems standards driven primarily by the commercial marketplace need to be a key element of the design and the architectural implications regarding the reuse of system/capabilities have to be thought through carefully.

  The engineering of individual applications and elements of the top-level system have to be worked using a disciplined process. Certainly, the integration of the overall system and all of its elements has to be a primary concern during all phases of development. This can be best done by defining a SIC. It is through the SIC that the infrastructure will be developed and the development engine will be made available for use in the variety of roles that have been defined.

- Demonstration Facility. The NCR demonstration facility provides senior service, DoD, and congressional executives with the ability to access the overall Battle Lab environment, monitor exercises, and observe tests or demonstrations of new C2 capabilities,

  There must also be a way to demonstrate a focus for this activity. There seems to be great utility in establishing a demonstration facility in the National Capitol Region. Since the discussion concerns a distributed system which allows collaboration among geographically disparate activities and organizations, the facility will be useful in demonstrating to key decisionmakers the capabilities and power of the C2 system and the underpinning of the development engine. On the other hand, for development of the system itself, there is a need for focus and management of the overall system, and that needs to reside with the principal developers of the C2 system.

- Implementation Examples. The development of the Joint Situation Awareness System (JSAS) provides an example of how the AF recently developed a new capability. It is informative to illustrate the preceding discussion regarding the use of the development engine by postulating how JSAS could have been developed if thc process as described were in place. Figure 5-7 depicts the process used for JSAS development.

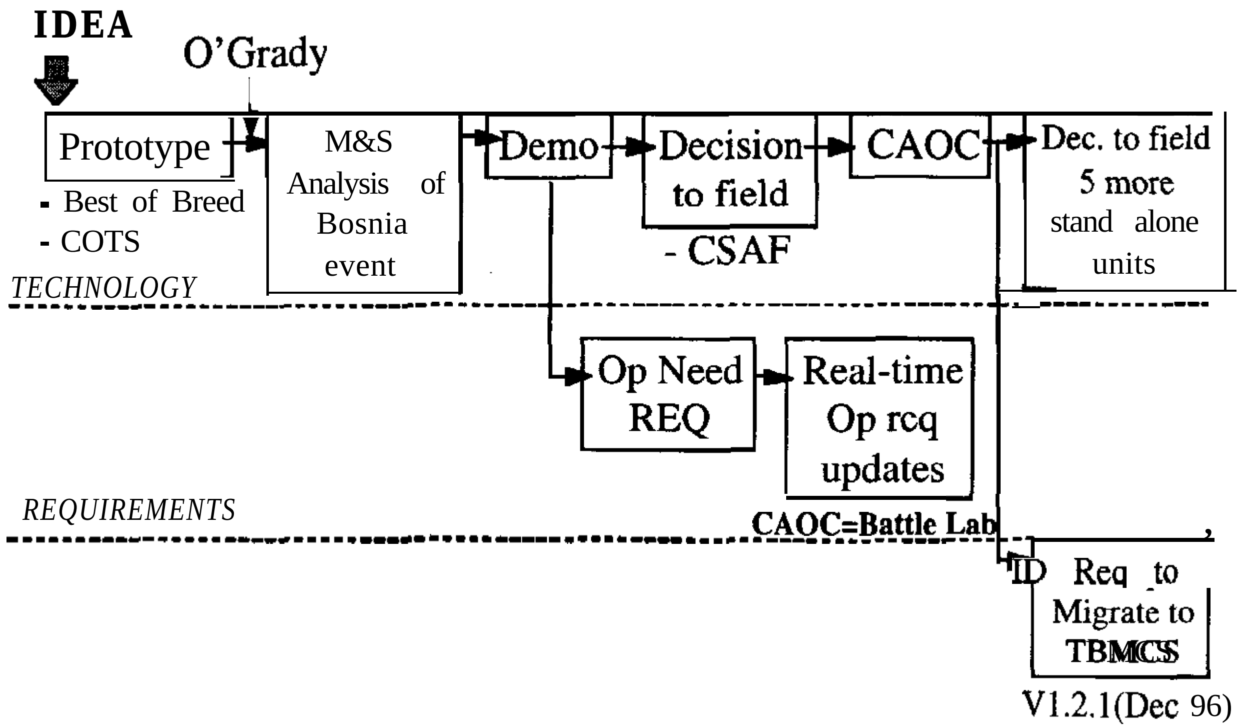


Figure 5-7. JSAS Example-History

The basic need for a tool for improved situational awareness for the commander was postulated some months ago within XORR. XORR had the funding and decided to examine the idea by building a prototype of the system and the supporting displays. They took a number of different ideas, all based on the use of COTS technologies with no developmental needs, and went through a best of breed process to select the approach that seemed to offer the greatest utility. Then in Bosnia, Captain O'Grady was shot down. This event triggered a greatly increased interest in the capability that was being suggested by JSAS and led to an analysis, through use of models and simulation, to achieve a better understanding of whether JSAS could provide capabilities that may have prevented the event occurrence. This led to a demonstration that was so persuasive that the Chief of Staff of the Air Force became the decision-maker. He made the choice to field JSAS in the CAOC at Vincenza for the Bosnian operation. The demonstration also triggered the normal operational requirements process. This need led to the definition of an operational requirement, and then led to the decision to include JSAS in the normal development process. To put this in the context of the earlier discussion, the CAOC in Vincenza became the battle lab or the tool used to perform the operational evaluation of the concept.

Because the JSAS proved its utility very quickly, there was a decision to field five more stand-alone units for use by the Air Force. Unfortunately, there had been no funding identified. The system itself is a stand-alone system; it does not interoperate with the other C2 systems that are being used in the CAOC. This led to a focus on how to both identify funding and how to get it fielded in a way that allowed it to interoperate with other capabilities. Ultimately, the decision was made to include this in the TBM Core Systems program. Funds were then identified to support the development and integration. It is now planned to migrate the capability into TBMCS with a version being available in Vincenza by December 1996.

A number of observations can be made from the development and fielding of JSAS. Clearly the requirements process broke down and required a catch-up. The failure to address requirements early led to a funding disparity and no direct plan for system integration. As a result, there was some difficulty in identifying the funds that would support the development of JSAS and certainly delayed the fielding of the additional units. The system was fun&d as a very specific stovepipe. It was fielded before there was any planning for how to integrate the system into the rest of the C2 structure at the CAOC. Clearly, there is additional cost to integrate it after the fact. The notional development approach using the process and the development engine described earlier is shown in Figure 5-8.

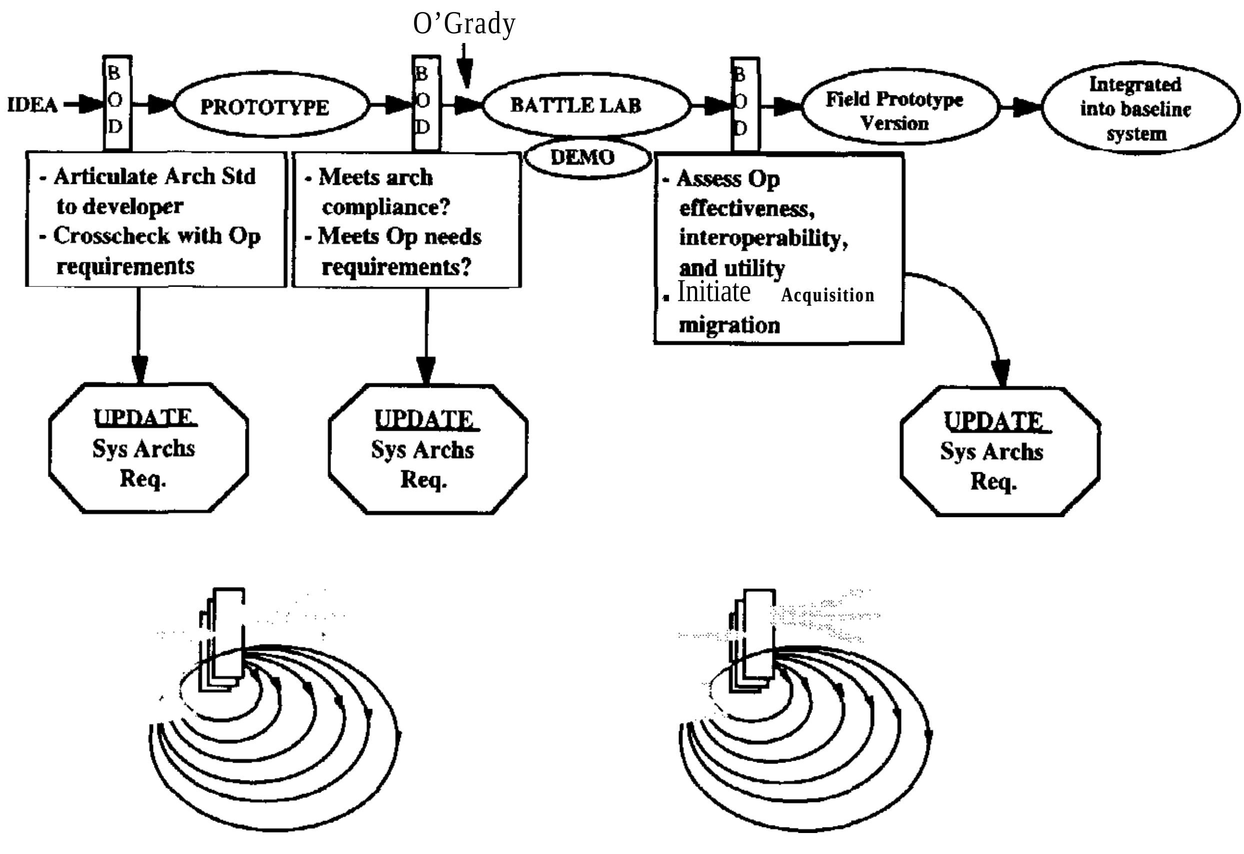


Figure 5-8. Another JSAS Example

The concept, which had funding, could have been brought to the BoD at an appropriate level, primarily to identify the fact that this development was going on and to articulate to the JSAS developers the architectural standards that needed to be satisfied to insure that the capability, if it was successfully demonstrated, would be able to integrated naturally into the overall system. The identification of changes to the operational system architecture begins at that time. As before, prototypes would be built using COTS components and the best of breed would be selected. The result would be presented to the BoD. At that point the BoD would check for compliance with the architectural standards and confirm that it did indeed meet the operational need. Assuming then that the O'Grady shoot-down had occurred, there would have been the clear desire to field the capability as soon as possible. A Battle Lab demonstration would be conducted and that demonstration would be an assessment of the operational effectiveness of the system and the interoperability with the rest of the C2 system.

As with the actual JSAS, the fielded prototype would have been immediately available. In this case, the system would have been interoperable because it had been planned from the beginning. The funding would have been identified, permitting the acquisition of whatever number of terminals or units were needed. Following fielding of that capability, the normalization of the system into the baseline system could be accomplished and the architecture could have been updated to reflect this new capability.

It is the SAB's opinion that tbis process would have led to a much more rapid and easily integrated capability. The rush for funding resources late in the game and the additional work needed to resolve the integration issues would have been accommodated from the start. In the end, the result would have led to a fielded capability incorporated into the overall C2 system in several fewer months than what actually is occurring with JSAS today.

- Training. It is clear that training is more than just what goes on in classrooms, whether the classroom is provided by the Air Education and Training Command or some other training element of the Air Force. Training encompasses every item and every activity that improves proficiency. Therefore, it becomes a necessity to regard training as a continuum. Training encompasses initial introduction to the system and its components through the way the system is employed in garrison, exercises, or ultimately in battle. It is fundamentally important to have people who are familiar with the systems when they are deployed, minimizing the amount of time it takes people to get up to speed in supporting the mission.

The conclusion from these observations is that training now needs to be built into the design of the baseline system and then ultimately into the design of every application system and every part of the platform. C2 system design must incorporate training requirements and provide the environment that supports training activities to ensure operator proficiency.

Figure 5-9 provides emphasis on the assertion that training must be regarded as a continuum that goes from the most elementary things to the most sophisticated. It must have its greatest impact on the lives of the people who are going to participate in deployments of any type. The platform engine must provide the services and support tools that facilitate the development of training for any element of the system. These features must be incorporated in the platform infrastructure to facilitate the common "look and feel" of the system. Figure 5-9 suggests a wide variety of features and capabilities that must be supported.

Information technology familiarity and skills will become essential for every member of the Air Force. All accession training programs should include the fundamentals of information systems and basic computer skills. The Battle Lab will be a critical training resource. As such, it must support all levels of training, from the schoolhouse level through refresher and upgrade training, Service, Joint, and coalition exercises, as well as recurring and recertification training for deployed units. Training must be embedded and accessible throughout the system. The ability to exercise a new capability, then reconfigure it to an operational mode, is a fundamental requirement.

As the C2 system gets more sophisticated in its fusion, display, decision support tools, and real-time control of airpower assets, the expertise and knowledge base that personnel operating the system gain will become a critical commodity to the Air Force. The personnel system must identify and manage these people throughout their careers. At some point, experience as a member of the C2 weapon system operational team may become a prerequisite for senior command positions.

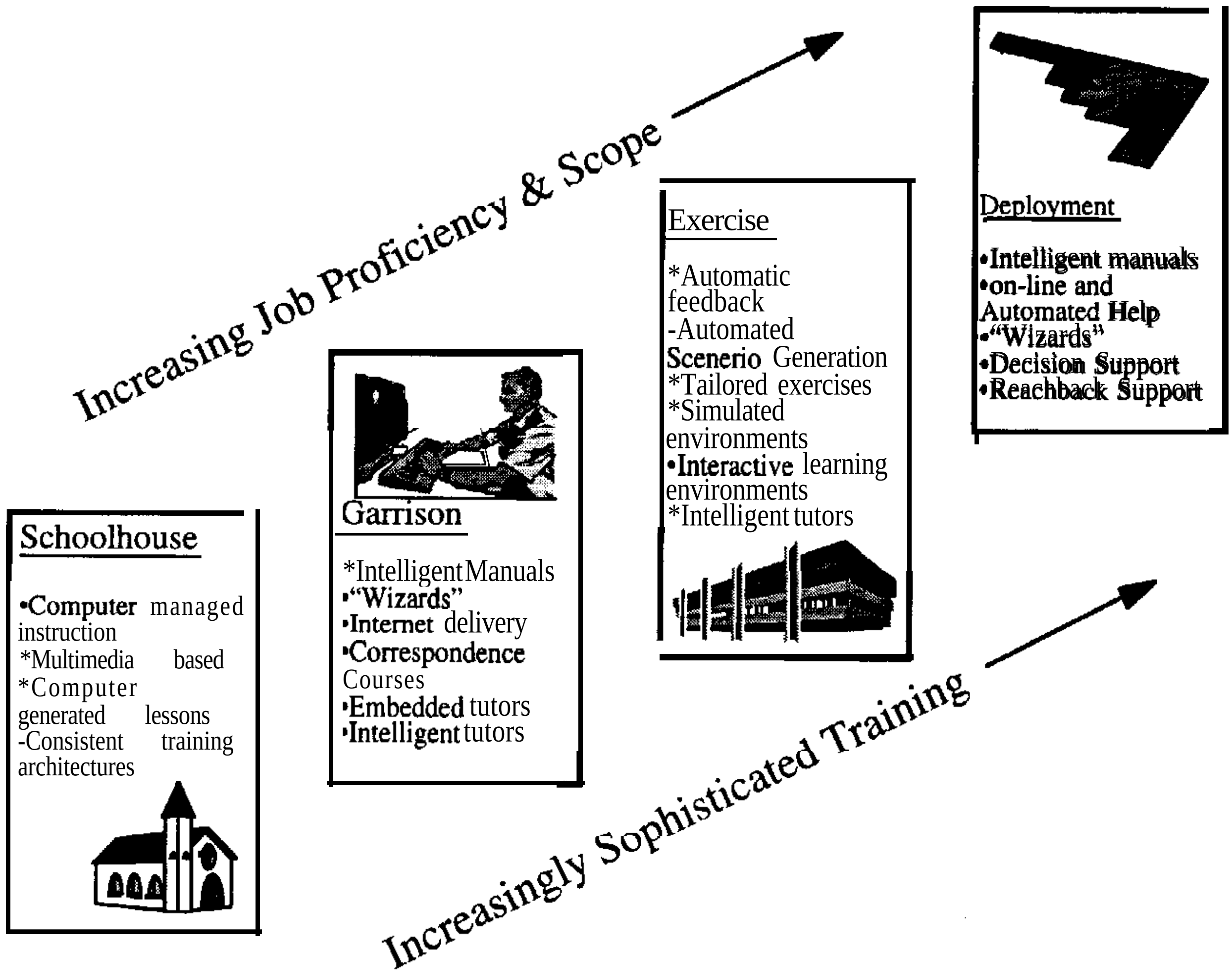


Figure 5-9. Notional Training Environment

5.5 The C2 Process-Implementation Recommendations

5.5.1 Enterprise Organizational Philosophy. The C2 Enterprise needs to be managed by a Board of Directors that will serve as the advocate for Command and Control in and for the Air Force. The Board of Directors should be a General Officer Steering Group (GOSG) whose membership is drawn from those elements of the Air Staff and the Major Commands that use and support elements of the command and control system. The GOSG should be supported in its day to day working functions by an O-6 Advisory Group, which would have a variety of IPTs or organizations focused on elements of their major responsibilities.

The BoD must put in place the evolutionary processes that will lead to the realization of the envisioned command and control system, including its continual revitalization. Clearly the management process must be put in place and the development engine must be created.

5.5.2 Air Force C2 Enterprise-Major Functional Responsibilities. Appendix D describes the functional responsibilities within the proposed C2 Enterprise. To emphasize the fact that C2 exists to support operations, the SAB believes that XO should be identified as the lead organization within the Air Force. A new organization should be created within XO, notionally identified as XOC, to indicate that in this organization, all of the activities associated with command and control across the operational Air Force am brought together.

The new XOC would then chair the GOSG. The organizations providing members on the Board of Directors for the Enterprise are indicated as supporters of the Strategic Planning process. In AQ, the obvious choice appears to be AQI. Each organization (i.e., SC, TE, LG, IN, and the MAJCOMs) must identify their general officer representative to the BoD. Certainly, ACC, AMC, Special Operations Command, Mobility Command, and Materiel Command should be included as members of the GOSG.

XOC would then have fundamental responsibility for resource planning and budgeting. A Command and Control Resource Management Panel needs to be created from existing panels. This Panel would be the Integrated Product Team supporting XOC and would develop input to the POM funding line. Finally, the system development role would be shared across product centers although there would be a concentration for much of the activities at Electronic Systems Center (ESC). The products centers that are responsible for developing a capability that will become part of the operational architecture of the C2 system would have the lead in accordance with the system that is being developed. They would be supported because of the need for user interaction, by appropriate individuals and organizations at the MAJCOMs, at the field operating agencies, and numbered air forces. More detailed planning should identify other support because the desire is to engage all users, whoever and wherever they may be in the Air Force.

Requirements for the overarching architecture for the C2 system should be identified by the operators. XOC would then become the focal point for architectural evolution, although they would delegate the detailed descriptions of the architectures to other organizations. Within the structure provided by the capstone requirements document, the major commands would provide their inputs and their vision of architectural needs in their mission areas. The MAJCOMs would be complemented by the FOAs associated with intelligence and possibly others.

The evolution of the platform and more generally, the development engine, will be primarily a very demanding engineering task. Therefore, ESC, which has the system engineering and integration capabilities to accomplish the task, should have that responsibility. A Systems Integration Center would be located at ESC and supported as appropriate by elements associated with SC. The office with responsibility for the overall C2 system, XOC, must be closely involved in the support of the platform evolution.

The MAJCOMs and FOAs wilt have major responsibilities within each of their mission areas for the application systems they need to support their roles and missions. They must identify deficiencies and inadequacies of the existing system and the operational architecture. XOC and the BoD will determine the applications that will merit evaluation and development. The early work will be done using the development engine so ESC will be the primary supporting organization. However, since ideas should be encouraged across the Air Force, there can be many organizations involved in proposing and assessing new capabilities. ESC's role will be to provide the common infrastructure and interface definitions to support the investigations. As systems complete their development and are fielded, the changes to the system will be reflected by changing the application baseline and its operational and system architectures.

5.53 Getting Started. The steps necessary to initiate the Enterprise are to:

- create XO directorate with responsibility for C2,
- charter the GOSG as Board of Directors (replacing TBM GOSG) to:

- ⇒ integrate financial planning in a single panel,
- ⇒ establish a program element and new strut in the FY98 budget estimate submission for infrastructure development,

- start a strategic planning function,
- build a prototype evolution process; i.e., the Battle Lab,
- establish a system engineering and integration function,
- establish a local demonstration facility to integrate current activities,
- establish the Combined Test Force.

Clearly, the first step requires the Enterprise itself to be created. The GOSG needs to be chartered to serve as the Board of Directors and serve as the focused voice for C2 in the Air Force and in the Air Force's dealings with the rest of the DoD and industry. This GOSG would replace the Theater Battle Management General Officers Steering Group, which has been in operation for the last several years and enjoyed a great deal of success. Within the operations directorate (XO), an organization, notionally referred to as XOC, should be formed that focuses on C2. All activities in XO that deal with C2 should be collected in this organization.

An integrated financial planning process should be established. This would help focus C2 into a single air staff panel which would replace the Information Dominance and C4 panels. As part of the responsibilities of the panel, it must be fully aware of financial investments in C2 that are being made across the DoD. The Air Force cannot afford to build a C2 stovepipe that operates with an absence of knowledge of what the investments are in other parts of the DoD.

Next, the Board of Directors should create a Capstone Requirements Document as soon as possible. Technology understanding and awareness also have to be brought to a focus. A Technology Program Integrated Product Team (or TPIPT) should be created to deal with all aspects of the technology that underpins command and control. The C2 TPIPT replaces the TBM TPIPT and must include within its charter all C2-related technology efforts in other TPIPTs. It is through this IPT that the management of the technologies referred to earlier becomes focused and directed.

Finally, current technologies can support the construction of the first version of the development engine. The combination of Fort Franklin and CUBE activities at ESC, the Battle Lab initiative within ACC, other initiatives at Rome Lab, and many other capabilities across the Air Force will allow the development of a distributed collaborative capability that was discussed in Chapter 3. This will require the identification of the funding and resources required to get started.

Appendix A

Command and Control Operational Phases and Tasks

Al.1 Introduction

Air and space operations contain general operational concepts or phases. These could occur at any, or all, levels of operation from operations other than war (OOTW) to major regional conflict (MRC). Under each concept or phase are basic objectives and tasks that provide a point to move from one to the next if the scenario dictates. These have been combined into three areas: Readiness and Deployment, Employment and Sustainment, and Reconstitution. Each will now be discussed.

Al.2 Readiness and Deployment

- Manage Forces and Resources. Commanders must have access to the status of their forces and resources 24 hours a day. Readiness and future deployment decisions are made on the accuracy and currency of this information. Command and control systems must provide the Commanders with a roll up look at the forces under them. They must be able to query and rapidly assess operational status of all items under their control. Management of forces can not occur without knowledge of the who, what, when, where, why, and how of their resources.

- Maintain Readiness. Units must operate in as close to operations conditions as possible. Operations from peace to war should only reflect a change in ops tempo to the airman, sailor, marine, and soldier. This requires information exchange with joint and coalition partners and realistic simulations and exercises. To achieve this, command and control systems must allow for tailored releasability to exercise as realistically as possible.

- Provide Intelligence/Warning/Threat Data and Assessment. Air Force intelligence, surveillance, and reconnaissance maintain global presence and awareness 24 hours a day. They are the eyes and ears of the forces in the state of readiness and are integral to the transition to the next stage of operations, This information must be available world-wide to all Commanders to maintain situational awareness. When a hot spot occurs, the command and control system alerts forces of possible movement orders. Forces must be alerted as soon as possible to ensure efficient force preparedness.

- Provide Courses of Action. Commanders must have real-time surveillance, reconnaissance, and intelligence analysis as well as analytical models to propose objective-oriented courses of action. Commanders must have the computer analysis tools to design options and a reliable communications infrastructure to present the best course of action up the chain of command. These are critical decision points, and projection of force will be based upon them. The control of surveillance and reconnaissance assets must be at a level to focus resources in the area of interest. Collection and analysis must be rapid, but just as important, must be accurate, using all knowledge available. This is the turning point for military operations.

- Increase Surveillance from Space, Air, and Ground Systems. As a course of action is determined, the tempo of surveillance and reconnaissance, focused in the area of interest, must be increased, with collection occurring from all sourcesÑspace, air ,and surface. All this information must be fused to form a complete picture of the area of interest. Information pouring into a Commander will not increase knowledge unless it can be related to other data and the operational problem that is being addressed. Also, information from areas outside the area of interest has no value added to the task at hand. Focused is the operative word, not increased.

- Provide In-Transit Visihilitv. To project force into a region, it is absolutely critical to control the forces during movement. This control must be accomplished with unrefuted knowledge on where forces are, at what time, where they came from, and where they arc going to meet an operational objective. The Commander must be able to direct and alter movement of forces *rapidly* to ensure limited resources are fed into the conflict at the right time and in the right place. The command and control system must be able to provide this level of information. The key is control of forces. Making a plan for force deployments and then not being able to control the execution of this plan for changes is called "loss of control."

  Just as important as controlling forces during movement, it is imperative to be able to know exactly what is on each aircraft or ship. This information can be rolled up to summary data if so desired, but a complete list is required from the command and control system. Commanders must know what is coming and where to direct the next action. A base or port needs to know the impact of the loads to ensure rapid and logical off-load. Units awaiting supplies or troops need to know when they will arrive and where they will arrive so they can be ready to receive them. Just as important to the Commander is the status of forces that will deploy from the air. The Commander must have complete visibility into these aircraft to direct or redirect the missions.

- Perform Mission Plannine. No force will go to an area of interest without some level of mission planning. The planning will outline the tasks required to meet the mission objectives. This planning could include the tasks of an amphibious operation, Army airborne assaults, initial deep strike interdiction, or fleet defense. The command and control system must support this planning effort with tools to develop and simulate planning options. The system must provide the most recent intelligence, surveillance, and reconnaissance information to conduct effective planning. These plans must be coordinated across areas of responsibility with the JFACC, JFLCC, and JFMCC to ensure an effective coordinated effort by all participants.

- *Increase AOR Surveillance from Space, Air, and Ground Systems.* As *forces* prepare to deploy and move into a region, surveillance operations need to be focused and increased. The demand for enhanced situational awareness to the Commanders will increase and the flow of information needs to be unchecked. Increasing the surveillance will have little utility if the Commanders are unable to receive the information quickly, and do not have the correct tools to analyze and determine the value of the information provided.

- Generate/Disseminate ATO/ACO Outside of AOR. To ensure coordinated operations arc mutually supportive across the region, an Air Tasking Order or Air Tasking Message and Airspace Control Order must be generated and disseminated to all participants. Direct communications are a must to forces moving to and within a theater. Since these forces are not predetermined, nor are they always at the same location, a global broadcast capability *will* be needed. Planning tools to develop the AT0 or ATM/ACO must have access to a global database. The global database must be accurate and updated often to ensure the planners have the most current information from which to plan, A plan must be built that responds to the Commander's objectives and tasks, and, as such, this information must be available to the planners. Video teleconferencing will be required for timely coordination. The dissemination must be timely and reach all forces for proper mission planning.

- Provide Threat Warning and Intelligence Reachback. With little or no warning of a operation, threat warning and intelligence reachback are important considerations for insuring all the information is available for fusion. As units deploy into a region, the command and control structure must handle the need for forces to reachback to the national or garrison locations to gain updatcs on information. Constant threat warning must be available to units as they enter a hostile area. Terrorism ongoing at a port or launching of surface to air missiles against an airlifterÑall must be provided without delay to the threatened party. Real Time Intelligence to the Cockpit (RTIC) is required. This information must be tailored to allow for the push of time-critical life threatening information, as well as the pull of intelligence and weather updates.

- Execute CONUS-Based Strikes. Strikes from the CONUS are a must to demonstrate the US projection of force and to clear an area for surface operations. The Air Force can achieve this within the constructs of Global Reach and Global Power. The command and control system must support this mission by providing intelligence, surveillance, and reconnaissance on a constant basis during the mission planning, in-route, and strike phases.

Al.3 Employment and Sustainment

- Manage Forces and Resources. Once in theater, management of forces and resources is critical to maintain the operations tempo. A Commander must stay ahead of the status of forces and be able to project when resupply will be needed. The command and control system must support the collection of information from all levels and all units. It must also provide a means to project shortfalls taking various operations tempos into consideration. There must also be a means to make this information available to other Commanders to ensure forces and resources across the theater are maintained.

- Generate/Disseminate ATO/ACO. The command and control system must support the JFACC's generation and dissemination of the AT0 or ATM/ACO for the theater. The information databases now need to be focused on the items available within theater that can be tasked and must include all activities being conducted to achieve the Commander's objectives. The AT0 or ATM/ACO must also address those missions coming into the theater, such as airlift and long-range bombing. The command and control systems must be integrated to provide this knowledge base.

- Perform Mission Plannine. Mission planning tools must have all the information to support the planning process. The most recent intelligence, reconnaissance, and surveillance must be available to be pulled for the particular mission area of interest. The AT0 or ATM/ACO must be integrated into the planning tools to save time and avoid errors.

- Disseminate Common Picture of the Battlespace. The Commander's situational awareness is an undefinable attribute, as it will depend on human personal traits and experiences. More information across a battlespace is not the answer. Graphical representations of the battlespace arc useless if they only show one aspect of air or surface. The command and control system must provide and make available to all Commanders in a broadcast mode a "recognize picture of the battlespace." This includes space, air, surface (land and sea), and subsurface and contains both blue and red forces. The information must be fused to avoid duplication of information and confusion. It must show real-time information and be updated within seconds or minutes and not days. It must be able to pull or push information to other participants. All Commanders must have the same view of the battlespace to make the knowledge based decisions on courses of action.

- Perform BDA and Intelligence Collection Manaeement. Rapid battle damage assessment, real-time intelligence, and efficient collection management are all cornerstones of mission success. The Commander must have control of the reconnaissance and surveillance **assets** to collect BDA immediately after an attack. The results must be made available in near-real-time back to the Commander to determine the next course of action. Intelligence must be constantly updated and made available to the Commander. Collection management must set priorities based on the operational objectives and tasks within the phase of operation and the Commander must be able to communicate these priorities to me collection managers to control the process.

- Conduct Dynamic Force Execution and Control. During mission execution, there will always be unforeseen changes. The command and control system must contain tools that allow a Commander to dynamically change the force employment dependent upon changes in situations. To ensure the change is geared towards the objectives, the Commander must have the most current situational awareness. The tool must be able to simulate or model the current situation and provide options for the Commander to assess and select. It must also present a future look at what, if any, this change in the flow will cause over the next few hours or days. This tool must be able to complete this analysis dynamically over minutes and not hours. A Commander must have fused information to allow for rapid retasking and replanning of assets within a AT0 or ATM timing cycle, be it 24 hours, 6 hours, or dynamically continuous.

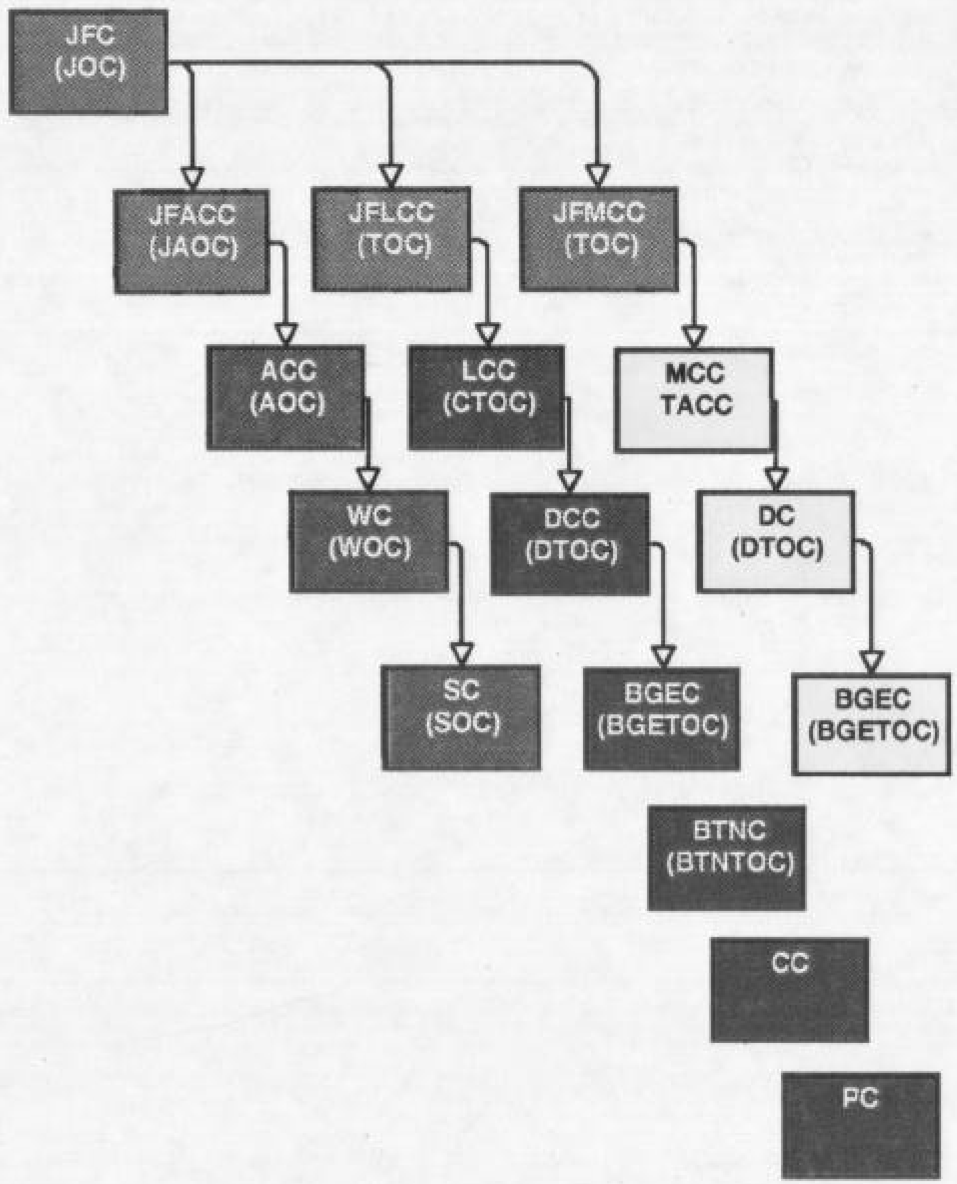
- Sustain Forces and Resources. The longer an operation continues, the more shortages are going to occur in forces and resources. The command and control system must keep pace with the databases, to include reachback look into CONUS sources for future planning.

- Provide Personnel and Base-Level Services. Again, as the operation continues, personnel and base-level services will be needed to avoid performance degradation. The command and control system must support global access to items that are more pleasure-oriented than battle-oriented. Internet, email, teleconferencing, movies, and television must be accessible from the support side of the command and control system.

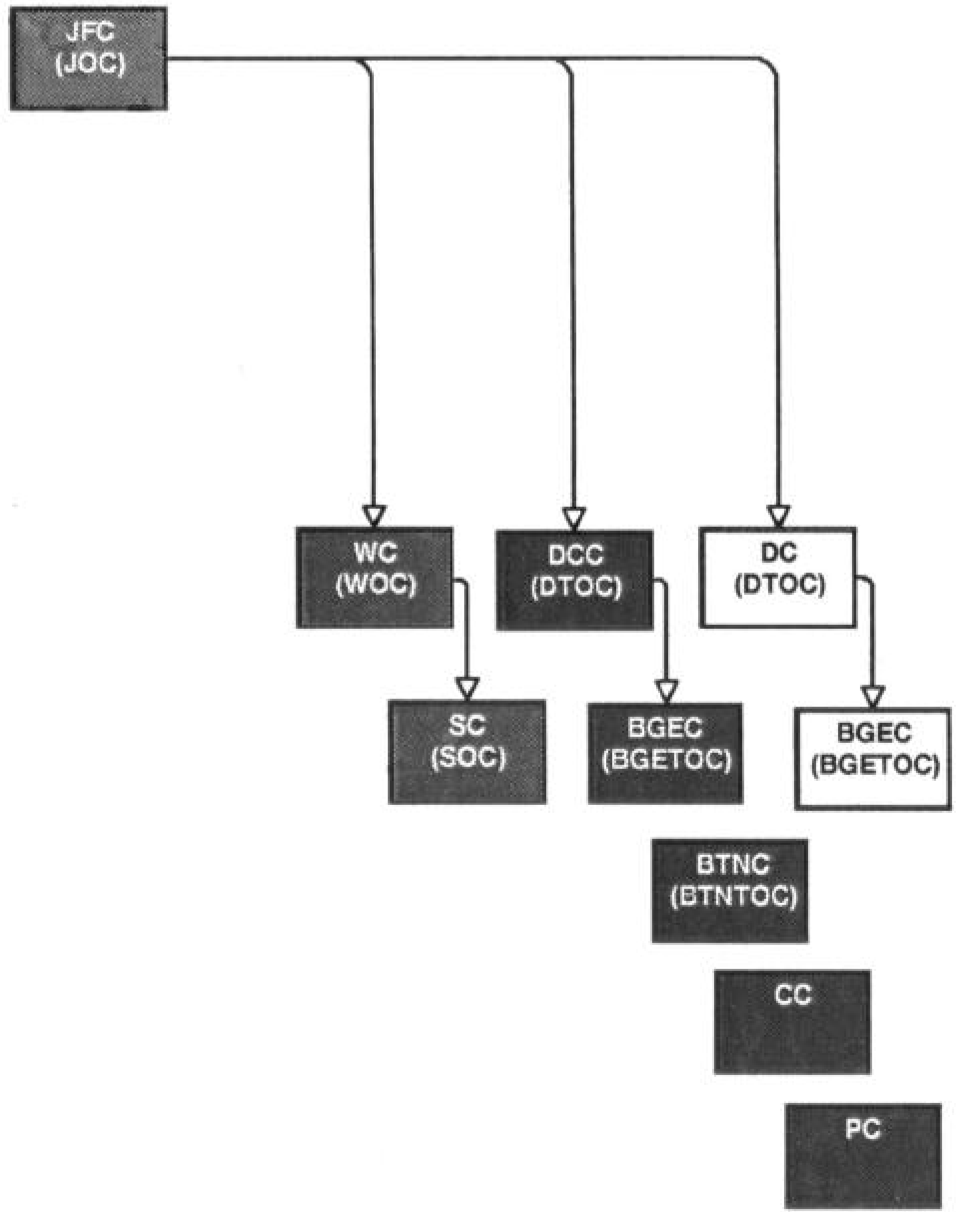
Al.4 Reconstitution

With the limited force structure and rapid mobility of forces, this phase may be returning to home or being redirected to another hot spot or area of interest. The actions that occur and the command and control system used would have to be split to meet this need. Command and control information will be directed globally anywhere, anytime. This vision would allow the control of forces during movement, provide in-transit visibility, maintain AOR surveillance, and provide threat warning and intelligence reachback using the same tools described above.

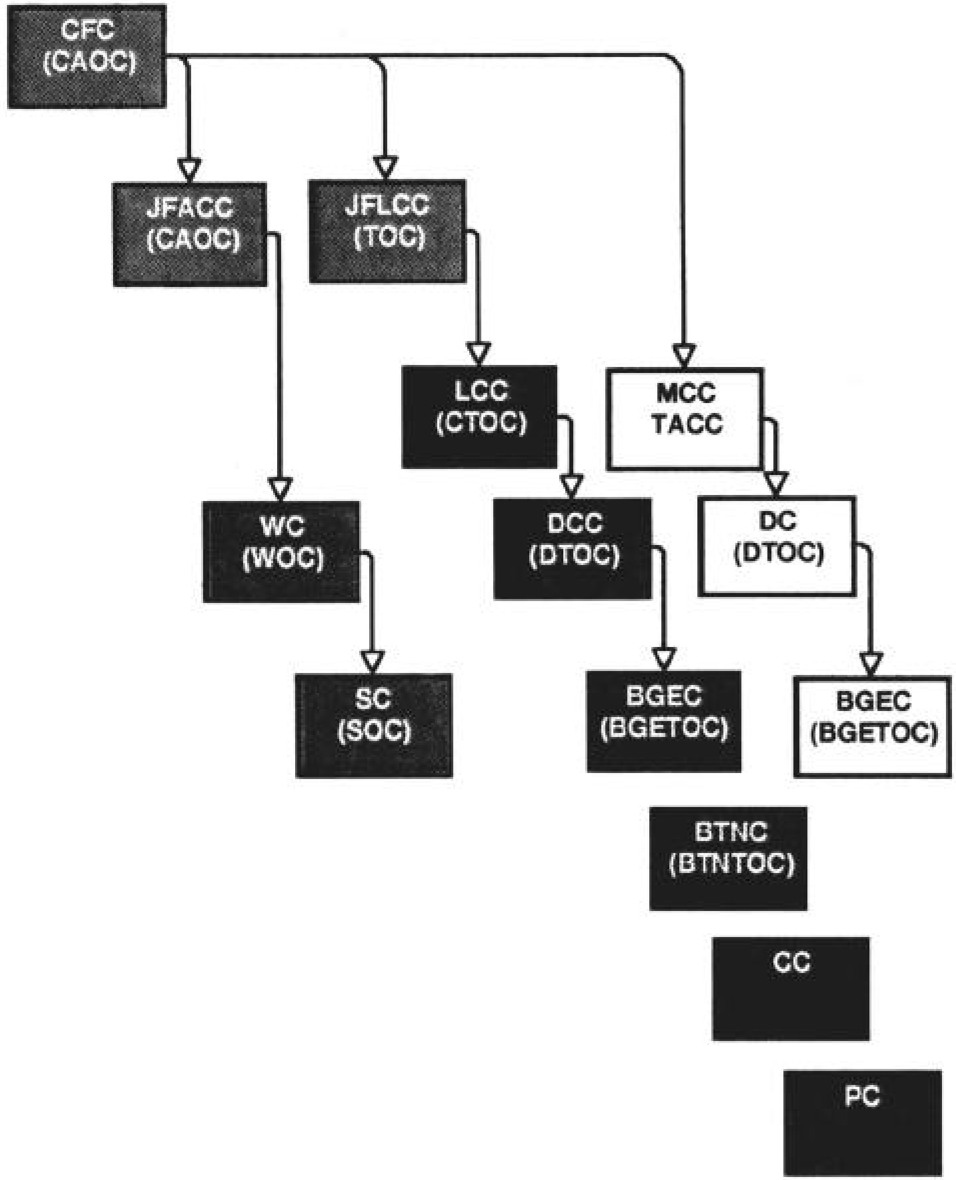
A Generic
Joint Command (and Operations Center) Hierarchy



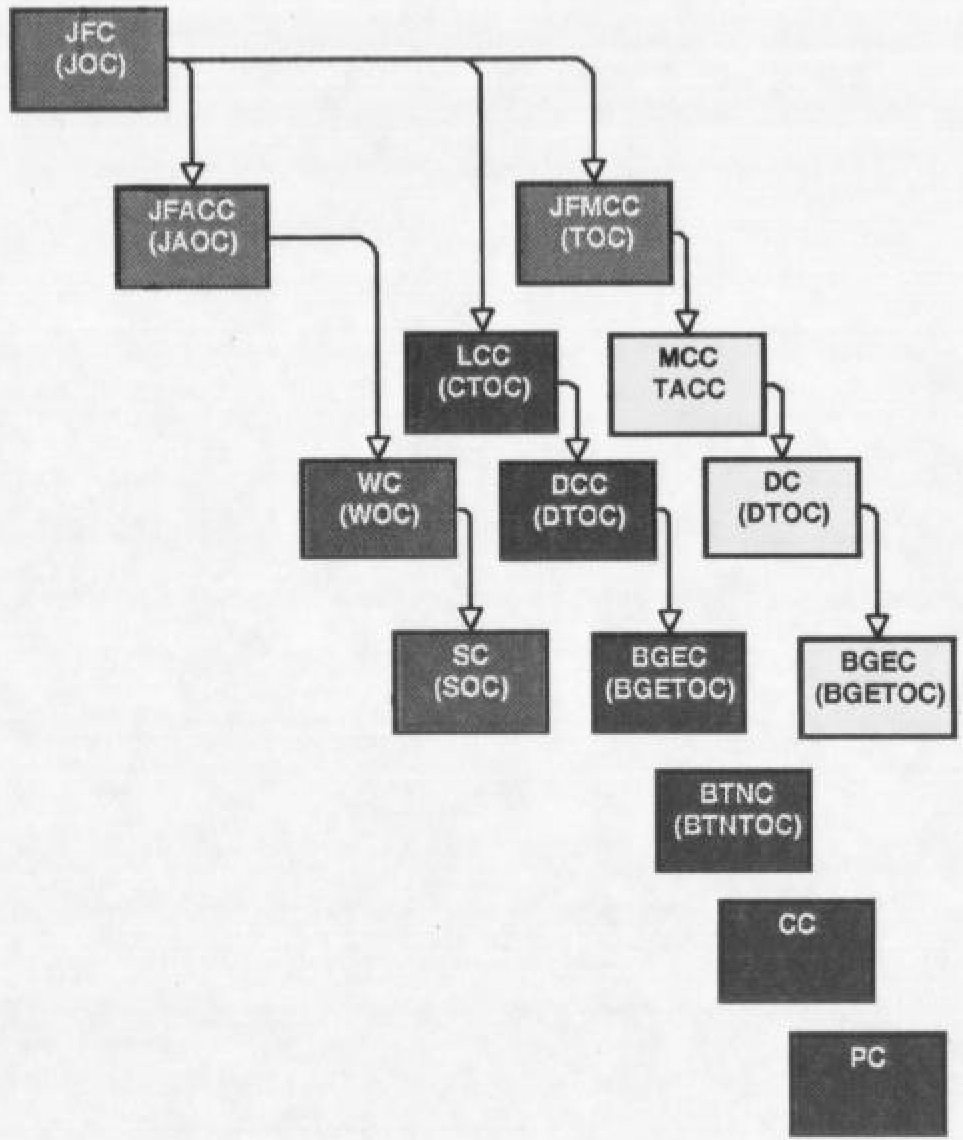
Example 1 - Haiti
Joint Command (and Operations Center) Hierarchy



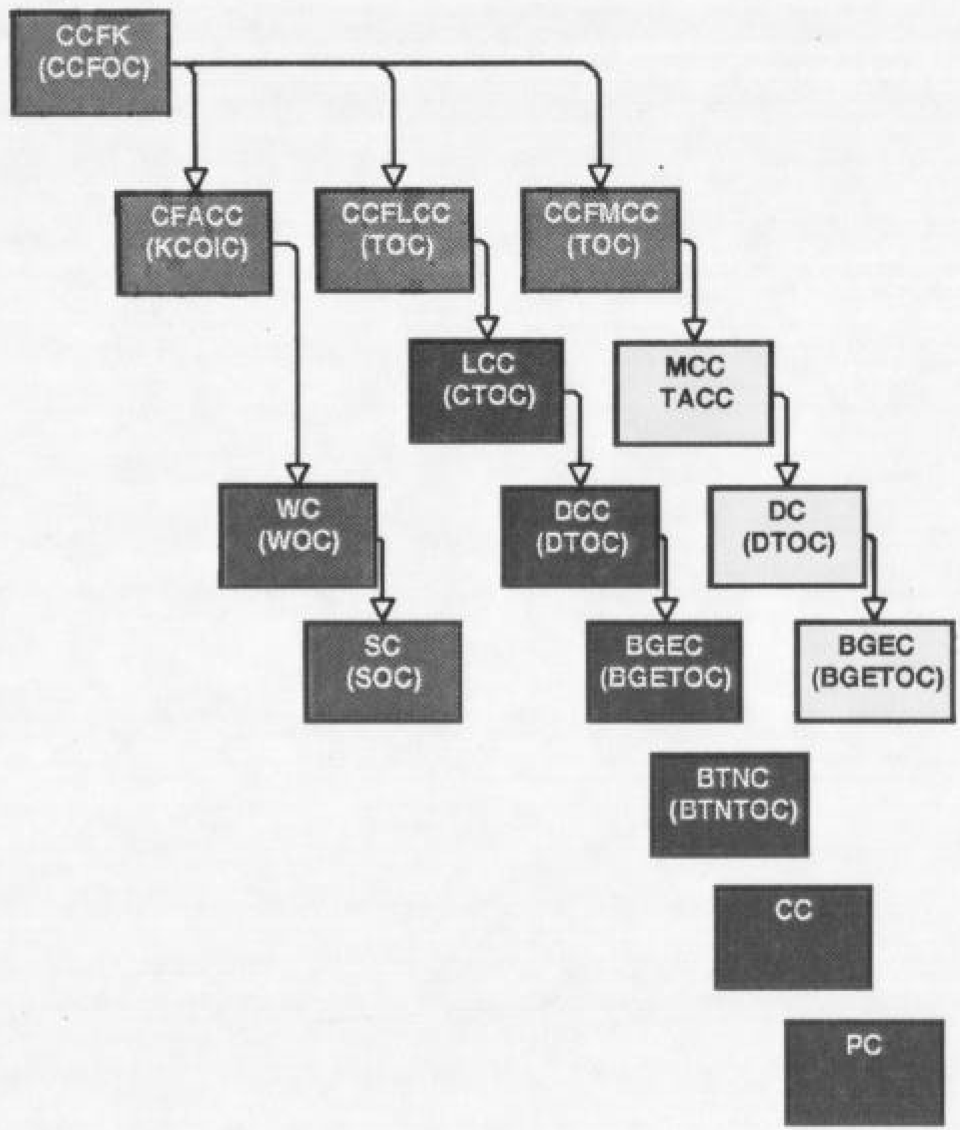
Example 2 - Bosnia
Joint Command (and Operations Center) Hierarchy



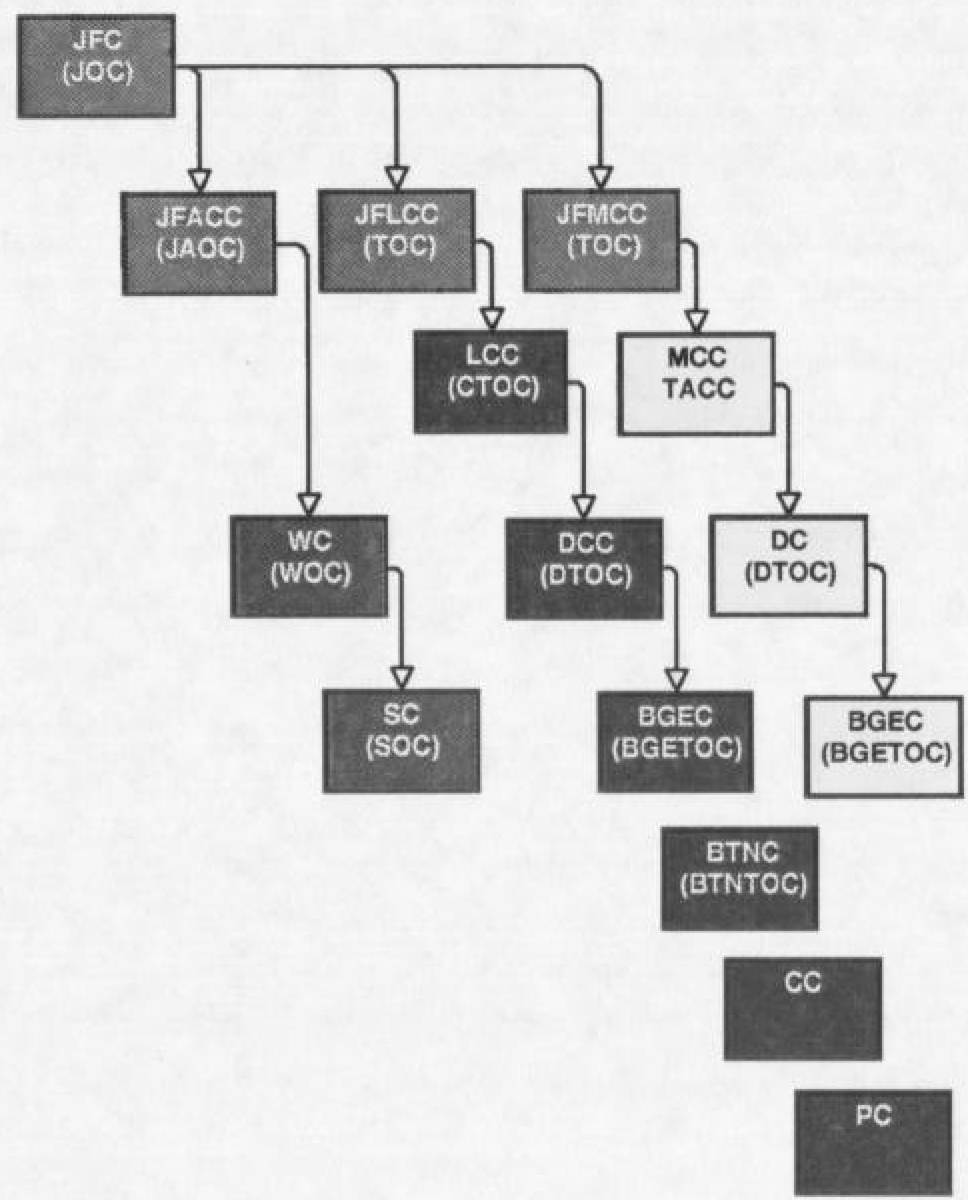
Example 3 - Desert Storm
Joint Command (and Operations Center) Hierarchy



Example 4 - Korea
Joint Command (and Operations Center) Hierarchy

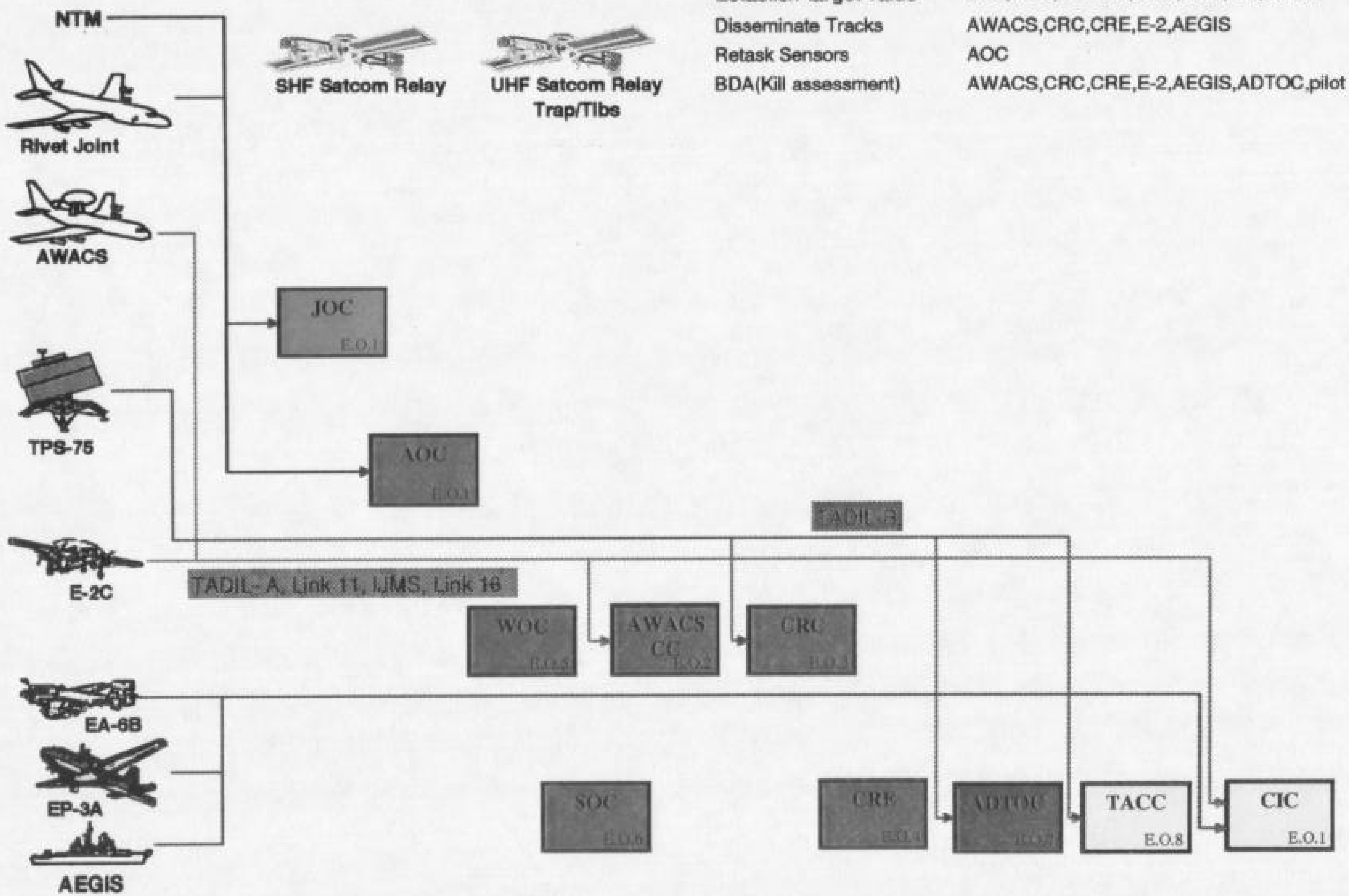


Example 5 - CENTCOM
Joint Command (and Operations Center) Hierarchy



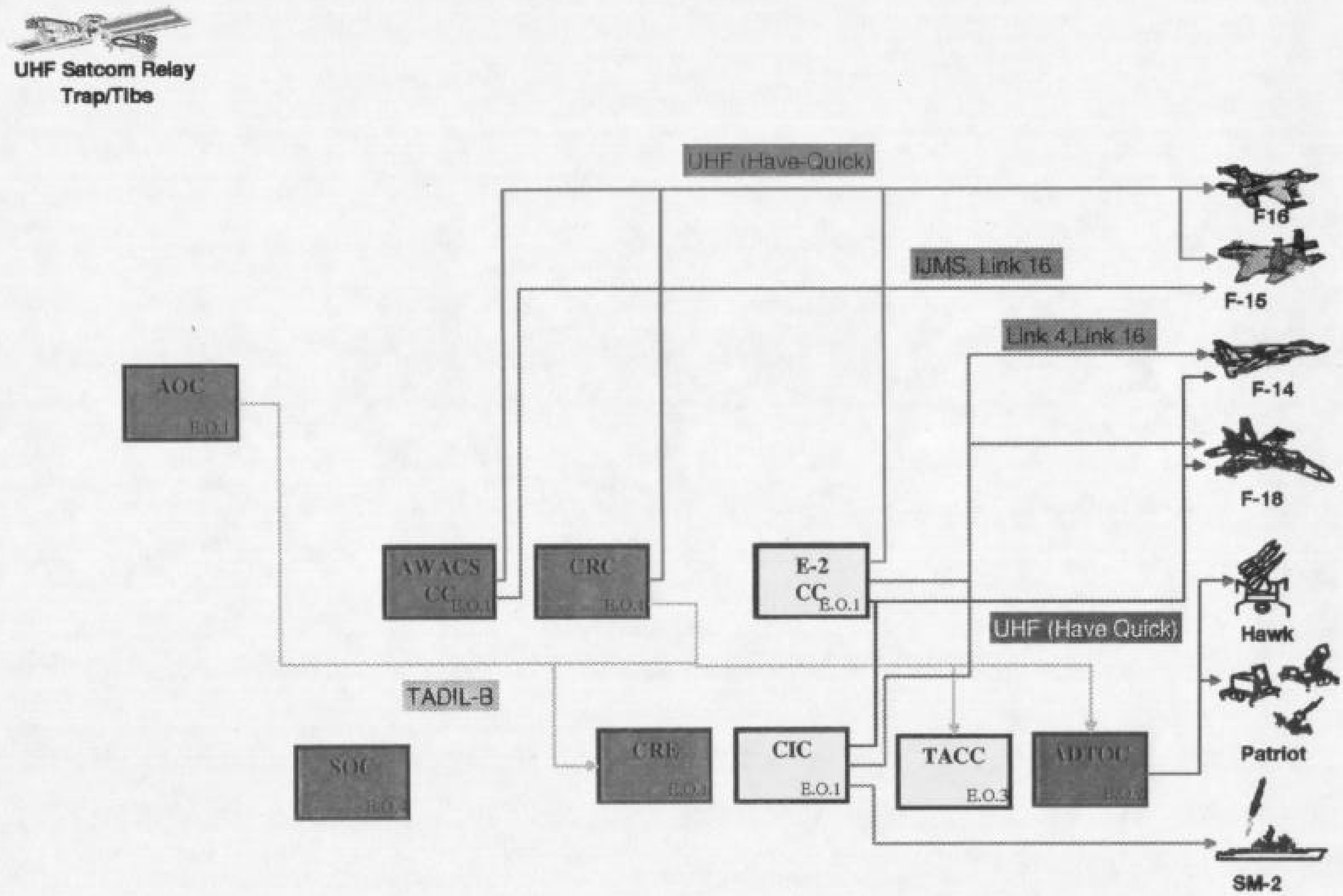
Defensive Counter Air
Combat Ops: C2-Sensor View
(fielded and prototype systems)

C2 Task	Delegatable C2 Elements
Initiate tracks	AWACS,CRC,CRE,E-2,AEGIS
ID tracks	AWACS,CRC,CRE,E-2,AEGIS
Update tracks	AWACS,CRC,CRE,E-2,AEGIS
Re-establish ID	AWACS,CRC,CRE,E-2,AEGIS
Track Correlation	AWACS,CRC,CRE,E-2,AEGIS
Multisensor fusion	AWACS,CRC,CRE,E-2,AEGIS
Establish target value	JOC,AOC,AWACS,CRC,CRE,E-2,AEGIS
Disseminate Tracks	AWACS,CRC,CRE,E-2,AEGIS
Retask Sensors	AOC
BDA(Kill assessment)	AWACS,CRC,CRE,E-2,AEGIS,ADTOC,pilot reports

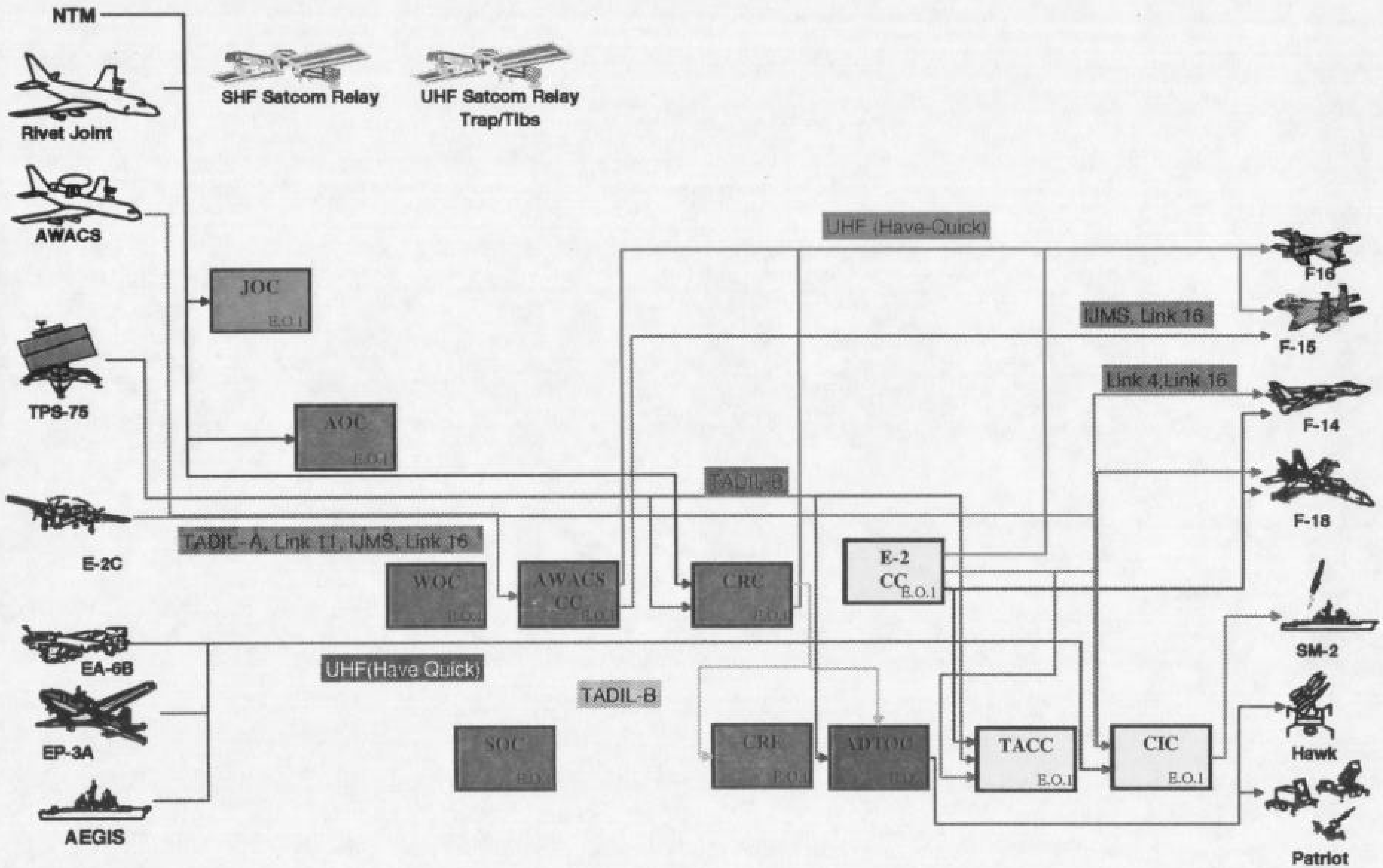


Defensive Counter Air
Combat Ops: C2-Shooter View
(fielded and prototype systems)

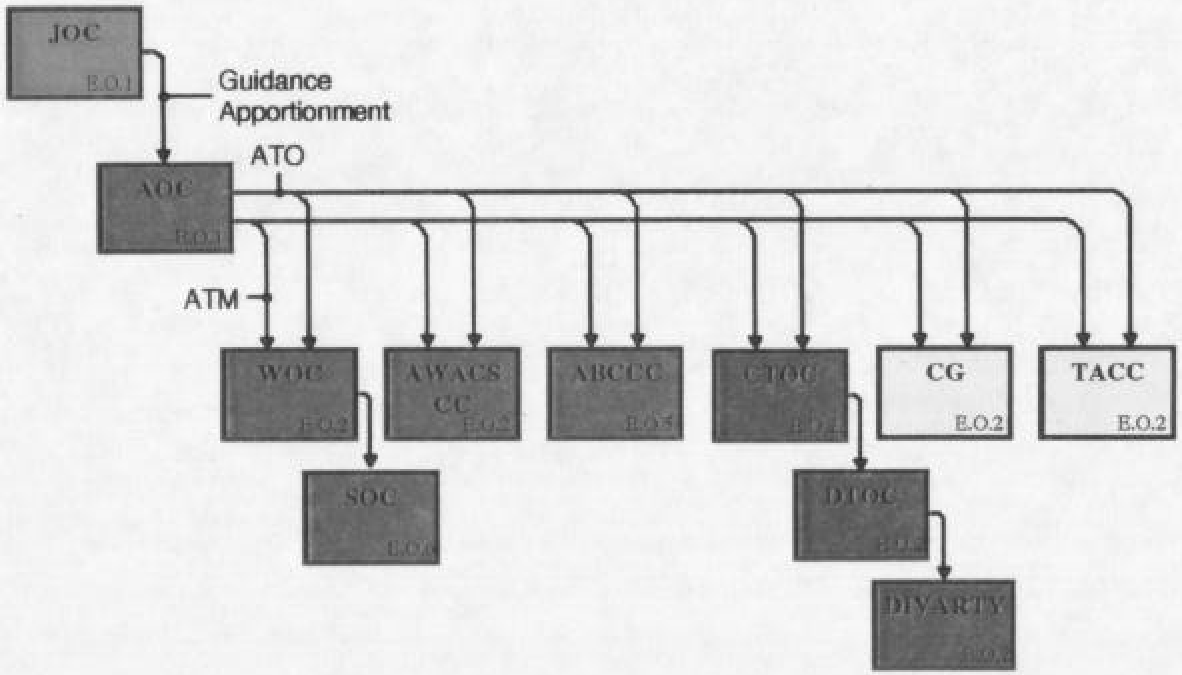
C2 Task	Delegatable C2 Elements
Target assignment	AWACS,CRC,CRE,C-2,ADTOC,CIC
Pass target data	AWACS,CRC,CRE,C-2,CIC
Engagement authority	AWACS,CRC,CRE,C-2,AEGIS,ADTOC
Threat warning	AWACS,CRC,CRE,C-2,CIC
Target reassignment	AWACS,CRC,CRE,C-2,ADTOC,CIC
Retasking	AOC,AWACS,CRC
Weather update	AWACS,CRC,CRE,C-2,CIC



Defensive Counter Air (DCA)
Combat Ops: C2 Element View
(fielded and prototype systems)

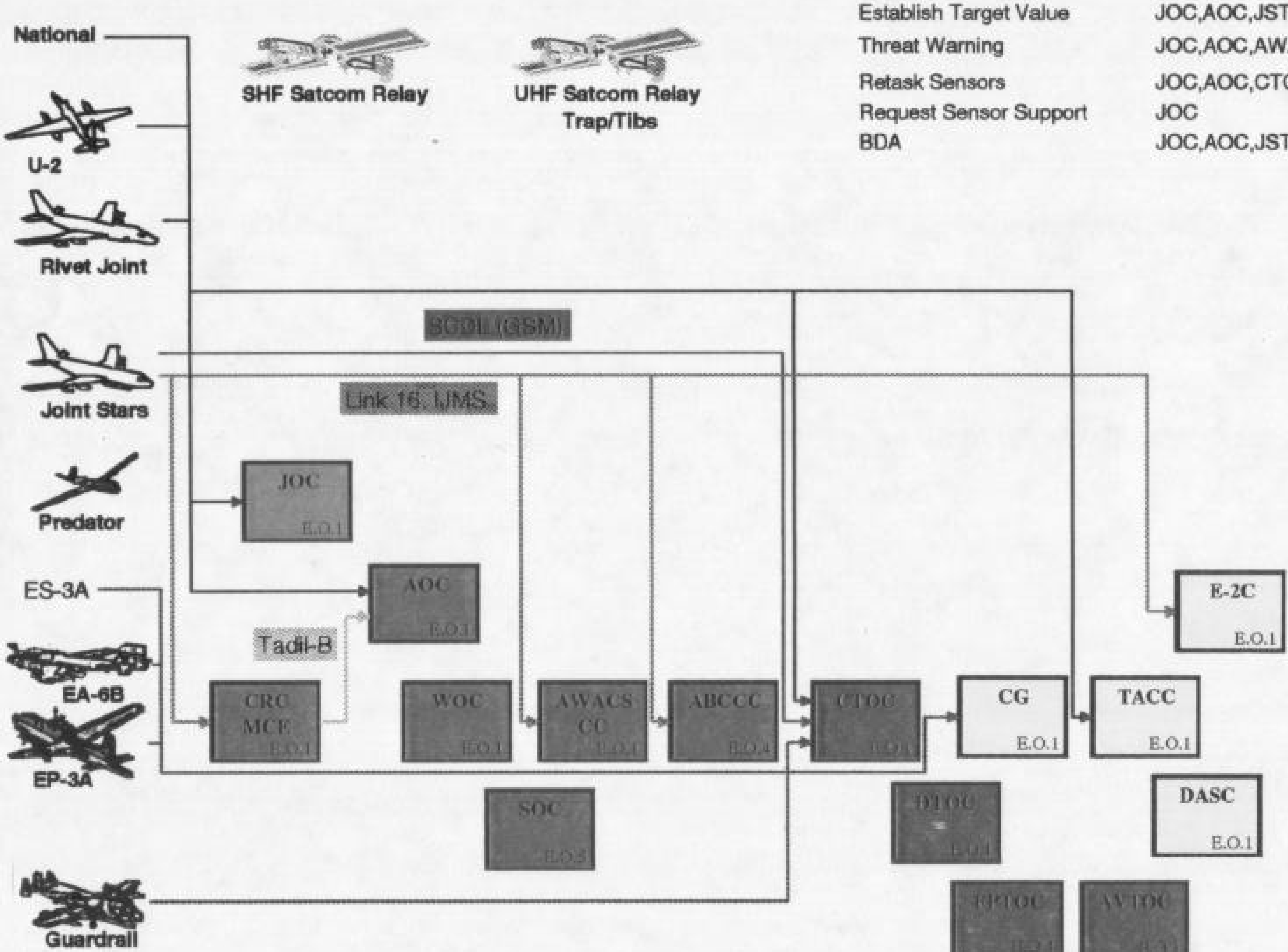


Interdiction (Moving Target)
Authority Delegation View
(fielded and prototype systems)

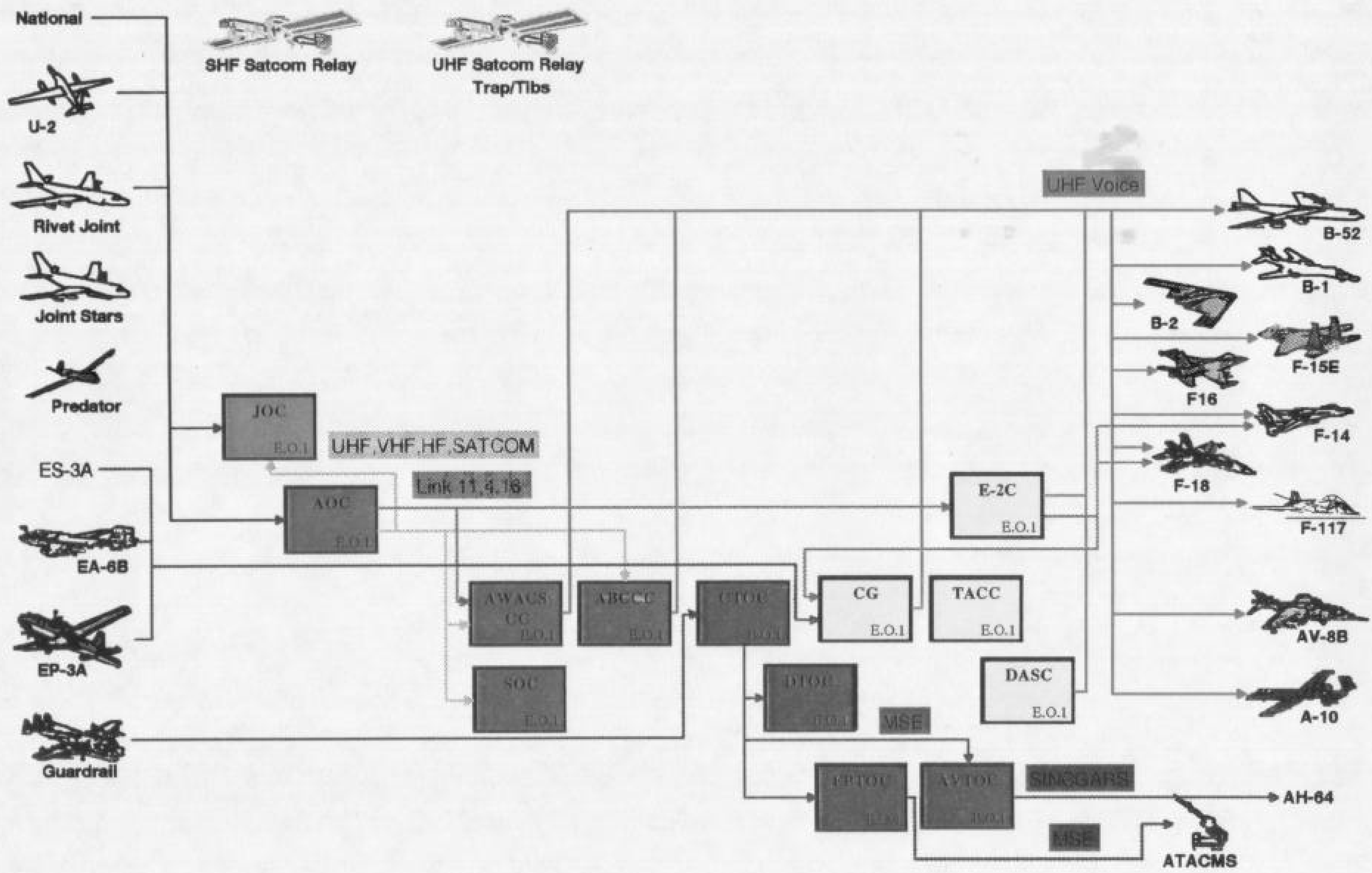


Interdiction (Moving Target)
Combat Ops: C2-Sensor View
(fielded and prototype systems)

C2 Task	Delegatable C2 Elements
Establish Tracks	JSTARS,CTOC
ID Tracks	JSTARS,CTOC
Update Tracks	JSTARS,CTOC
Re-establish Track ID	JSTARS,CTOC
Correlate Tracks	?
Multi-sensor Fusion	JOC,AOC,CTOC(?)
Disseminate Tracks	JSTARS
Establish Target Value	JOC,AOC,JSTARS,ABCCC(?)CTOC
Threat Warning	JOC,AOC,AWACS,CRC,CRE,ABCCC(?)CTOC
Retask Sensors	JOC,AOC,CTOC
Request Sensor Support	JOC
BDA	JOC,AOC,JSTARS,CTOC,CG,TACC,Pilot reports



Interdiction (Moving Target)
Combat Ops: C2 Element View
(fielded and prototype systems)



Appendix C

Technology Roadmap for Vision

Cl.1 Introduction

Among the critical issues facing tbe USAF are decisions of what to buy and what to develop internally for its command and control systems. There are numerous commercial technologies that are readily adaptable to military needs (e.g., satellite direct broadcast technologies and CORBA). In addition, there is a significant match between USAF technologies and development programs underway at DARPA, various government laboratories, and agencies of the government. An overview of these programs is shown in Table C-l below.

Table C-l. Summary of Key USAF Command and Control Technologies

Technology	**Significant** Relevant **Commercial R&D?**	**Significant** Relevant Government **R&D** (Planned or in Progress)
Fusion:		
-ATR	-no	-DARPA SAIP, WL, RL, PL, CIA, USA, AFOSR
-multi-target tracking	-no	-DARPA DMIF II, WL, RL NSA. USN
-multi-sensor data fusion	-no	-DARPA DMIF II, WL, RL NSA, USA
Communications:		
-pointing airborne antennas	-no	-WL, RL
-software radios	-yes	-DARPA/RL Speakeasy, USA, WL/ASC
-mobile networking	-yes	-DARPA GloMo, WL, USA
-fixed networking	-yes	-GCCS, RL
-direct broadcast satellites	-yes	-DARPA BADD. USAF. USA, USN
Planning & Collection Management:		
-interactive planning	-yes	-DARPA JFACC, DARPA CM, RL., AFOSR
-scheduling	-yes	-DARPA JFACC, DARPA CM, RL, AFOSR
-collaboration	-yes	-DARPA 13
Information Protection:		
-encryption	-yes	-DARPA, NSA
-protective software	-yes	-DARPA, NSA
Platforms for Technical Reference Architectures:		
-POSIX, Net protocols, GOSIP	-yes	-GCCS COE, DMS
-Middleware	-yes	-GCCS COE/LES, DARPA
-CORBA	-yes	-GCCS LES
-software for network-based computation (agents, etc.)	-yes	-DARPA BADD, AFOSR
-large multimedia databases	-yes	-DARPA BADD, DARPA I?

Particular attention should be paid to those technologies that have no direct commercial analogs. It should also be noted that even in cases where a commercial analog exists, substantial funds may be needed to transition the technology to USAF applications.

One of the more striking things about Table C-l is that DARPA is directly and heavily involved in most of the relevant USAF command and control technologies. A key strategy for the USAF should be to support and team together with DARPA in those areas where R&D programs are initiated that are directly relevant to the Air Force's future. Some of these programs, such as JFACC, are well funded by DARPA and require only the concerted support of USAF technical managers. Others (e.g.. DARPA ISO's newly forming ISR collection management initiative) could benefit from both financial and technical management support fmm the USAF.

The point has been made in the Vision statement that the key technologies of the future for the USAF will be netted airborne communications, fusion, planning, and allied supporting technologies. These are integrated into the system-level view shown in Figure C-l.

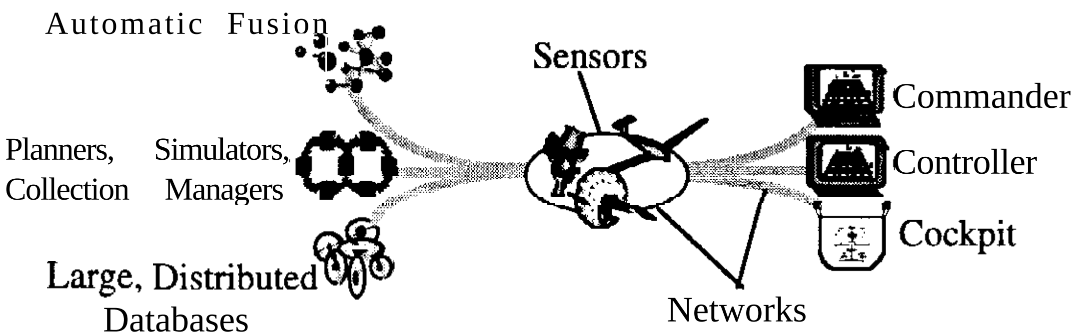


Figure C-l. System-Level View of Key Technologies

The advent of networked communications for mobile applications in the commercial and military world will have a dramatic impact on USAF mission environments, as shown below in Figure C-2. In this example, netted communications and rapid automatic fusion/planning enable a cooperative operation with just-in-time weapon-target assignment, integrated ops/ISR planning, and remote control.

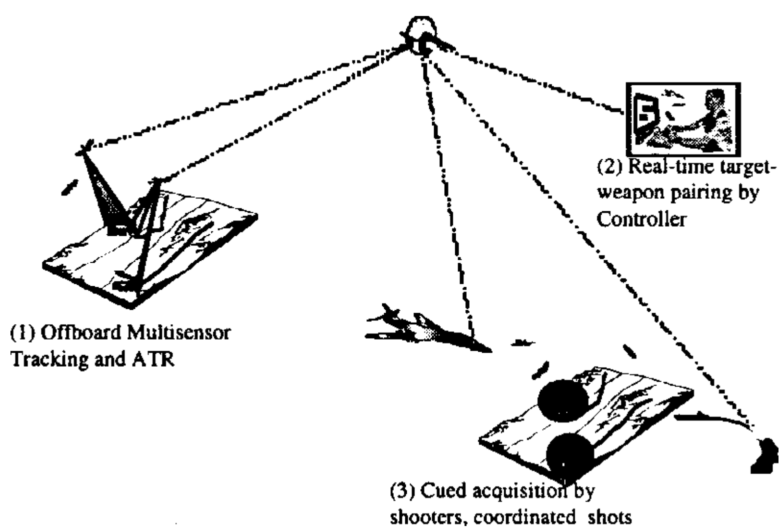


Figure C-2. Typical Mission Environment for Future Command & Control

Tbe USAF must acquire through the most cost-effective means possible the technologies to enable such missions. It is not clear that the direct use of other Services' capabilities (such as the USN Cooperative Engagement Capability) will be viable for the USAF. However, careful attention should be paid to such design concepts, and the USAF should join with *other* Services and agencies with a goal of cost sharing and technology integration.

The specific technologies that are recommended are shown in Table C-2. As a result of funding commitments made after the USAF SAB New *World Vistas* study, funding lines of approximately $28M were established for early (6.1) research in several of these areas, notably fusion and planning. However, the critical 6.2-6.3 funding lines have not been adequately focused in most of these areas.

Table C-2. Specific Technology Areas to Pursue for Future Command & Control

	*Automatic Fusion:* software for automatic tracking, ATR, and multimedia fusion (consistent architecture: shooter avionics, UAV avionics, widebodies, ground C2 sensors)
	*Planning, Simulation & Collection Management:* rapid automated planning and execution software, collaboration tools, and joint scheduling of sensor assets
	*Commander/Controller/Aircrew Aides:* software to gather information from the network, adaptively filter and present for the task at hand (user programmable)
	Networks: satellite and UAV routing, GCCS, software radios/low cost antennas, mobile intemet protocols for aircraft, gateways to joint networks, direct broadcast and two-way digital links
	Sensors: greater geo-accuracy, better reolution, faster frame rates, evolution toward fire-control quality
	*Large, Distributed Databases* : stores and disseminates common air/surface picture/plans, mediators, wrappers, data mining

In the 6.2-6.3 funding lines, programs need to be established for the following technologies:

- Mixed-Initiative, Continuous Planning

  ⇒ Objective: High performance planning teams composed of human and intelligent computer agents engaged in a continuously rolling planning process distributed spatially, temporally, and organizationally.

  ⇒ Benefit: Continuous planning horizon spans entire conflict so dependency relationships between early decisions and temporally distant effects can be identified, reasoned out, and maintained. “Least commitment” decision making enables real-time opportunity cost management leading to more responsive, more efficient, more robust campaigns characterized by “just-in-time” tasking.

- Collaborative Systems and Groupware

  ⇒ Objective: Virtual planning process collaborative within and across organizational structures.

  ⇒ Benefit: Distributed, collaborative planning focuses on multi-agent planning at the task level, above the level of group ware. Technical issues involve the negotiation of planning objectives, resources, responsibilities, and priorities and the establishment of an information-rich, shared planning context through joint training and exercise.

- Integrated Ops/ISR Planning and Scheduling

  ⇒ Objective: The ability to do collection management as an integrated part of theater battle management. Focused on direct control of multiple air breathing reconnaissance assets, manned and unmanned, and collaborative use of non-theater assets through new automated planning and scheduling technology.

  ⇒ Benefit: Tighter linkage of theater activities to objectives will provide opportunities for better allocation of ISR assets planned concurrently with Ops to collect precisely those key signatures of critical importance to real-time campaign assessment and to better management of change through localized plan impact analysis.

- Multimedia Fusion Methods

  ⇒ Objective: Systems that go beyond situation awareness to situation understanding; using methods of symbolic computation and inference to fuse many disparate sources of knowledge. Develop means of predicting enemy intent and analyzing relationships among objects in the battlespace. (These are processing steps usually associated with Levels 2 and 3 of the JDL fusion model.)

  ⇒ Benefit: Higher quality fusion results when imaging and video information is available, better ability to deal with non-scripted operations, and richer human-computer interaction.

- Airborne Networked Communication

  ⇒ Objective: Affordable conformal antennas, high data rate LPI comm, software-based radios and network protocols are necessary to connect tactical aircraft to the Grid via satellites and UAVs. Innovation in antenna architecture, fabrication and installation, cost driven software-based radio architectures, wide band LPI techniques, and dynamic network protocols should be developed. Issues include structural arrays that can be built into the skin of the vehicle, self-correcting architectures and algorithms, array structure design for low RF & IR cross-section, and new waveforms and modulation techniques.

  ⇒ Benefit: Critical high bandwidth LPI communications links for awareness and execution in over-the-horizon operations.

Cl.2 Summary

There are a host of allied technologies needed to support the vision of future USAF command and control. In the discussion above, several key areas of focus are identified along with the need to team with DARPA and other parts of the government and industry to acquire needed capabilities.

An overview of the entire range of enabling command and control technologies is provided in the figures below. Not all of these can be funded by the Air Force alone, but all have a bearing on its future.

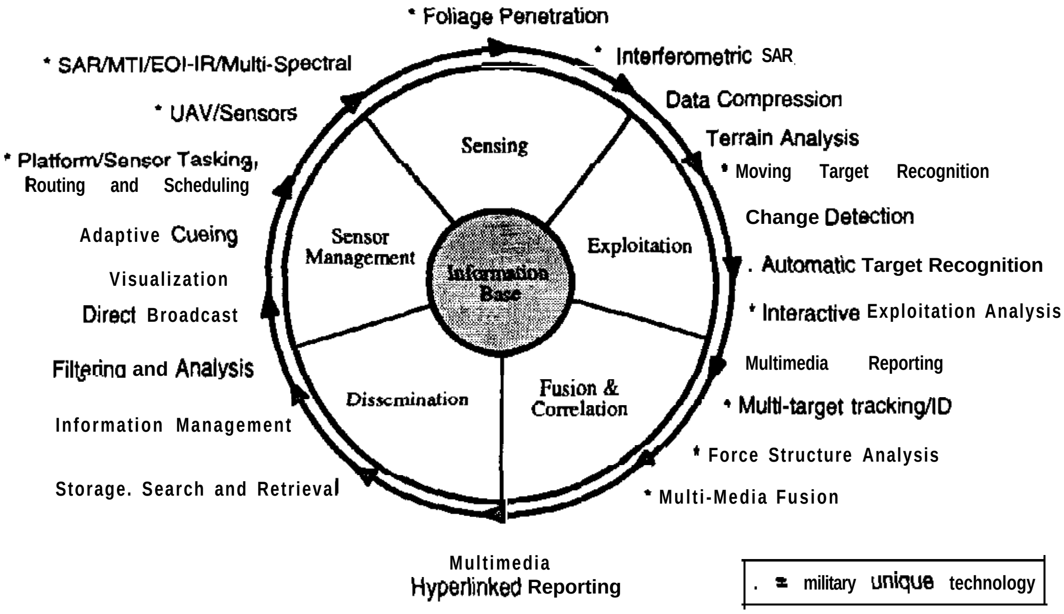


Figure C-3. Enabling Technologies for Global Awareness

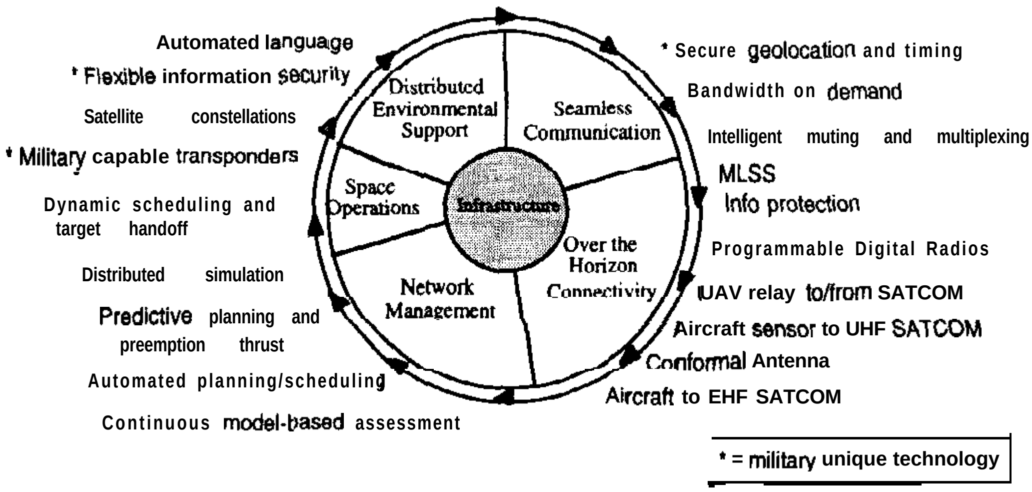


Figure C-4. Enabling Technologies for Connectivity

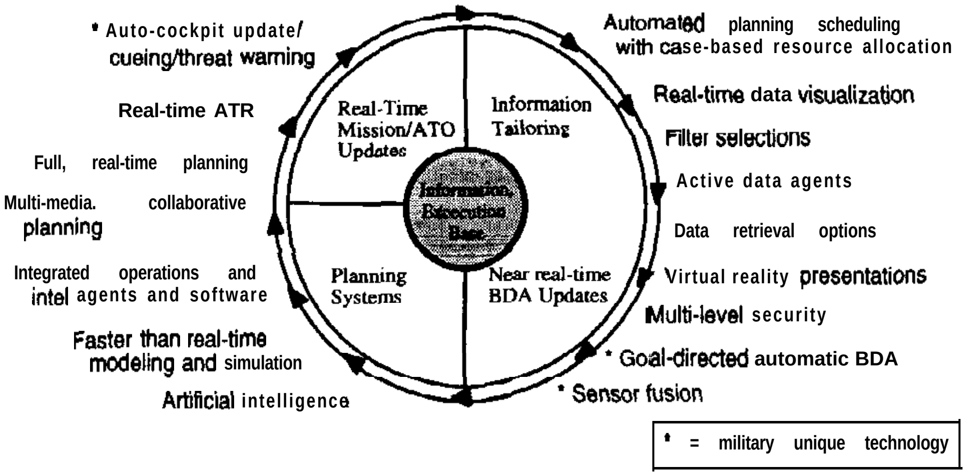


Figure C-5. Enabling Technologies for Dynamic Planning and Execution

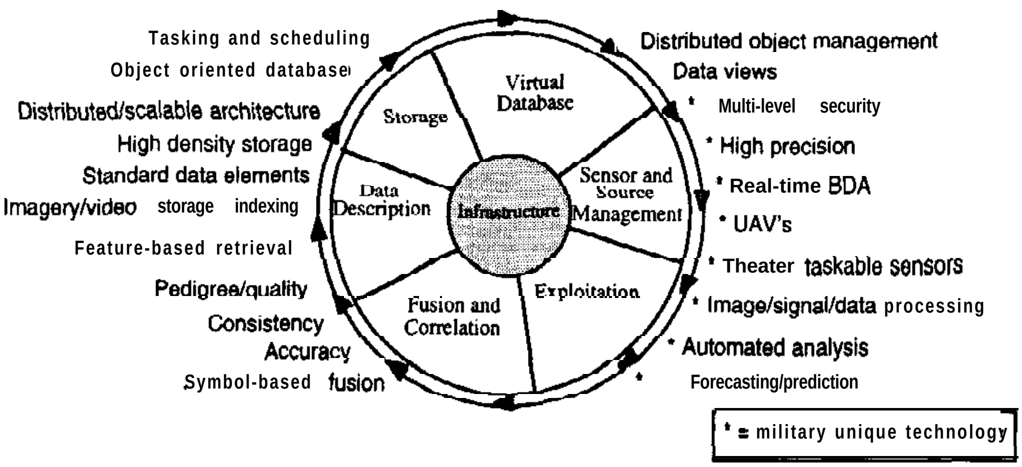


Figure C-6. Enabling Technologies for Databases and Knowledgebases

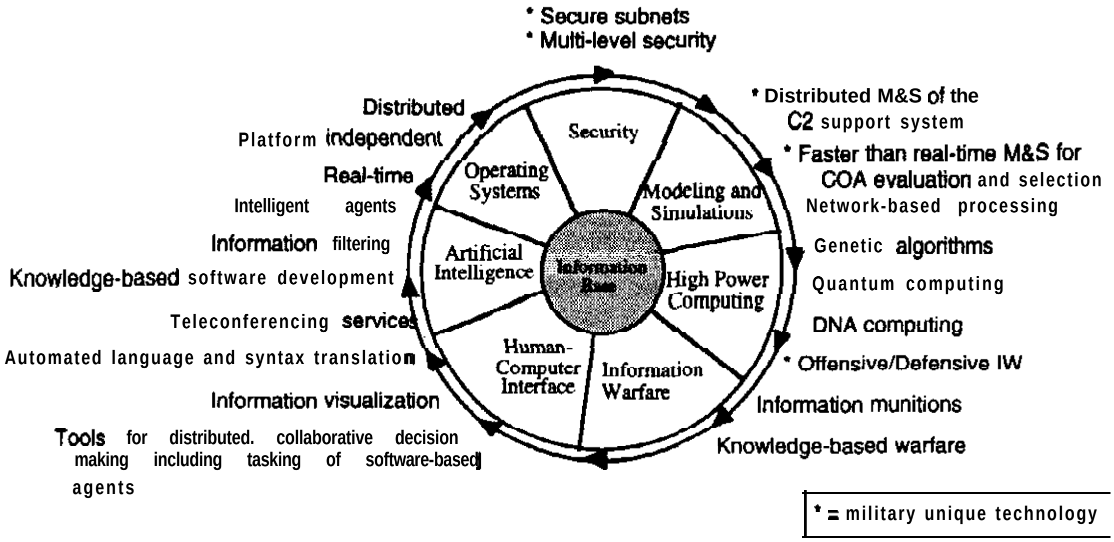


Figure C-7. Enabling Technologies for Common Computing Environment

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APPENDIX D

AIR FORCE C2 ENTERPRISE RESPONSIBILITIES AND IMPLEMENTATION

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Air Force C2 Enterprise
Major Functional Responsibilities

Function	What does it need?	What does it produce?	Who leads?	Who supports?
Strategic Planning	• User needs • Technology forecast • Defense planning guidance • Joint C2 plans • Financial plans	• Vision and Roadmap • CRD • Long-term investment strategy	• XOC	• AQI • SC • TE • LG • IN • MAJCOMs
Resource Planning and Budgeting	• Strategic planning products	• POM funding line	• XOC	• C2 Resource Mgt. Panel
C2 System Development and Fielding	• New applications • Development engine • C2 architecture	• Upgrades to system baseline • Training updates	• Product Centers • PEOs	• MAJCOMs • AFBL • FOAs • NAFs

Air Force C2 Enterprise
Major Functional Responsibilities (cont.)

Function	What does it need?	What does it produce?	Who leads?	Who supports?
Architecture Evolution	• Vision and Roadmap • Execution Status • Map/MNS • CONOPS • COTS and DoD standards and specifications • New ideas	• Architecture • Architectural compliance	• XOC	• MAJCOMs • FOAs • ESC • SC • AFBL
Platform Evolution	• Funding line • Architecture • Current deficiencies • New opportunities	• Changes to product baseline • Identifies architectural deficiencies and limits	• ESC	• SC • AFBL • XOC
Application Improvement	• Funding line • Architecture • Platform interfaces and services • Current deficiencies • Current requirements • New opportunities	• Changes to application baseline • Identifies architectural deficiencies	• MAJCOMs • FOAs	• XOC • ESC • AFBL

Development Engine Implementation

	Primary Organization	Supporting Organizations	Primary Resource	Supporting Resources	Tasks
Analysis & Modeling	• XOC	• XOM • Developer • C2 Architects • User	• Modeling Center	• Warfare Simulations • Environment Simulations • DSC	• Normalize Concepts to C2 Architectures • Operational Effectiveness Evaluation • Cost Estimates
Prototype & Simulation	• Developer	• XOC • C2 Architects • User • Dev. Engine Manager	• Development Labs	• System Integration Center • Modeling Center • Environment Simulations • Warfare Simulations • Battle Lab	• Standardization Evaluation • Operational Effectiveness Evaluation • Cost Estimates • Product Maturity • Prototype
Battle Lab	• Developer	• User • Dev. Engine Manager • C2 Architect • CTF	• Battle Lab	• System Integration Center • Environment Simulations • Warfare Simulations	• Architecture Compliance • Operational Effectiveness • Cost Estimates • Preliminary CONOPs & Tactics

Development Engine Implementation (cont.)

	Primary Organization	Supporting Organizations	Primary Resource	Supporting Resources	Tasks
ACTD	• XOC • OSD	• Developer • C2 Architects • User • Dev. Engine Manager	• Battle Lab	• System Integration Center • Environment Simulations • Warfare Simulations	• Operatonal Effectiveness • Force Structure Requirements • Cost Estimates • CONOPs & Tactics • Residual Assets
Operational Evaluation	• User	• CTF • Dev. Engine Manager	• Battle Lab • JBC	• Environment Simulations • Warfare Simulations	• Operational Suitability • CONOPs & Tactics • Training
Exercise	• User	• Dev. Engine Manager	• Battle Lab • JBC	• Environment Simulations • Warfare Simulations	• CONOPs & Tactics • Training • Readiness Evaluation

Appendix E

Glossary

air defense. All defensive measures designed to destroy attacking enemy aircraft or missiles in the Earth's envelope of atmosphere or to nullify or reduce the effectiveness of such attack.

(Joint Pub l-02)

air interdiction. Air operations conducted to destroy, neutralize, or delay the enemy's military potential before it can be brought to bear effectively against friendly forces at such distance from friendly forces that detailed integration of each air mission with the fire and movement of friendly forces is not required.

(Joint Pub l-02)

air operations center. The principal air operations installation from which aircraft and air warning functions of combat air operations are directed, controlled, and executed. It is the senior agency of the Air Force Component Commander from which command and control of air operations am coordinated with other components and Services. Also called AOC.

(Approved for inclusion in the next edition of Joint Pub l-02)

air superiority. That degree of dominance in the air battle of one force over another which permits the conduct of operations by the former and its related land, sea and air forces at a given time and place without prohibitive interference by the opposing force.

(Joint Pub l-02)

air support request. A means to request preplanned and immediate close air support, air interdiction, air reconnaissance, surveillance, escort, helicopter airlift, and other aircraft missions. Also called AIRSUPREQ.

(Approved for inclusion in the next edition of Joint Pub l-02)

air tasking order. A method used to task and disseminate to components, subordinate units, and command and control agencies those projected sorties/ capabilities/forces to targets and specific missions. Normally provides specific instructions to include call signs, targets, controlling agencies, etc., as well as general instructions. Also called ATO.

(Approved for inclusion in the next edition of Joint Pub l-02)

air tasking order/confirmation. A message used to task joint force components; to inform the requesting command and the tasking authority of the action being taken; and/or to provide additional information about the mission. The message is used only for preplanned missions and is transmitted on a daily basis, normally 12 hours prior to the start of the air tasking day or in accordance with established operation plans for the theater of operations. Also called ATOCONF.

(Approved for inclusion in the next edition of Joint Pub J-02)

airspace control authority. The commander designated to assume overall responsibility for the operation of the airspace control system in the airspace control area.

(Joint Pub l-02)

airspace control order. An order implementing the airspace control plan that provides the details of the approved requests for airspace control measures. It is published either as part of the air tasking order or as a separate document. Also called ACO.

(Joint Pub J-02)

airspace control plan. The document approved by the joint force commander that provides specific planning guidance and procedures for the airspace control system for the joint force area of responsibility. Also called ACP.

(Joint Pub l-02)

allocation (air). The translation of the apportionment into total numbers of sorties by aircraft type available for each operation&ask.

(Joint Pub l-02)

allocation request. A message used to provide an estimate of the total air effort, to identify any excess and joint force general support aircraft sorties, and to identify unfilled air requirements. This message is used only for preplanned missions and is transmitted on a daily basis, normally 24 hours prior to the start of the next air tasking day. Also called ALLOREQ.

(Approved for inclusion in the next edition of Joint Pub l-02)

allocation. In a general sense, distribution of limited resources among competing requirements for employment. Specific allocations (e.g., air sorties, nuclear weapons, forces, and transportation) are described as allocation of air sorties, nuclear weapons, etc.

(Joint Pub l-02)

allotment. The temporary change of assignment of tactical air forces between subordinate commands. The authority to allot is vested in the commander having combatant command (command authority).

(Joint Pub l-02)

apportionment (air). The determination and assignment of the total expected effort by percentage and/or by priority that should be devoted to the various air operations and/or geographic areas for a given period of time. Also called air apportionment.

(Approved for inclusion in the next edition of Joint Pub l-02)

architecture. A framework or structure that portrays relationships among all the elements of the subject force, system, or activity.

(Joint Pub l-02)

area air defense commander. Within a unified command, subordinate unified command, or joint task force, the commander will assign overall responsibility for air defense to a single commander. Normally, this will be the component commander with the preponderance of air defense capability and the command, control, and communications capability to plan and execute integrated air defense operations. Representation from the other components involved will be provided, as appropriate, to the area air defense commander's headquarters. Also called AADC.

(Joint Pub l-02)

area of influence. A geographical area wherein a commander is directly capable of influencing operations by maneuver or fire support systems normally under the commander's command or control.

(Joint Pub l-02)

area of interest. That area of concern to the commander, including the area of influence, areas adjacent thereto, and extending into enemy territory to the objectives of current or planned operations. This area also includes areas occupied by enemy forces who could jeopardize the accomplishment of the mission.

(Joint Pub l-02)

campaign plan. A plan for a series of related military operations aimed to achieve strategic and operational objectives within a given time and space.

(Joint Pub l-02)

close air support. Air action by fixed- and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the tire and movement of those forces. Also called CAS.

(Joint Pub 1- 02)

combatant command (command authority). Nontransferable command authority established by title 10 ("Armed Forces"), United States Code, section 164, exercised only by commanders of unified or specified combatant commands unless otherwise directed by the President or the Secretary of Defense. Combatant command (command authority) cannot be delegated and is the authority of a combatant commander to perform those functions of command over assigned forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction over all aspects of military operations, joint training, and logistics necessary to accomplish the missions assigned to the command. Combatant command (command authority) should be exercised through the commanders of subordinate organizations. Normally this authority is exercised through subordinate joint force commanders and Service and/or functional component commanders. Combatant command (command authority) provides full authority to organize and employ commands and forces as the combatant commander considers necessary to accomplish assigned missions. Operational control is inherent in combatant command (command authority). Also called COCOM. See also combatant command; combatant commander; operational control; tactical control.

(Joint Pub l-02)

combatant command. A unified or specified command with a broad continuing mission under a single commander established and so designated by the President, through the Secretary of Defense and with the advice and assistance of the Chairman of the Joint Chiefs of Staff. Combatant commands typically have geographic or functional responsibilities. See also specified command, unified command.

(Joint Pub l-02)

command, control, communications, and computer systems. Integrated systems of doctrine, procedures, organizational structures, personnel, equipment, facilities, and communications designed to support a commander's exercise of command and control across the range of military operations. Also called C4 systems.

(Approved for inclusion in Joint Pub l-02)

command and control. The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

(Joint Pub l-02)

command and control system. The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned.

(Joint Pub l-02)

command and control warfare. The integrated use of operations security (OPSEC), military deception, psychological operations (PSYOP), electronic warfare (EW), and physical destruction, mutually supported by intelligence, to deny information to, influence, degrade, or destroy adversary command and control capabilities, while protecting friendly command and control capabilities against such actions. Command and control warfare applies across the operational continuum and all levels of conflict. Also called C2W. C2W is both offensive and defensive: a. counter-C2—To prevent effective C2 of adversary forces by denying information to, influencing, degrading, or destroying the adversary C2 system. b. C2- protection-To maintain effective command and control of own forces by turning to friendly advantage or negating adversary efforts to deny information to, influence, degrade, or destroy the friendly C2 system.

(Joint Pub I-02)

command center. A facility from which a commander and his or her representatives direct operations and control forces. It is organized to gather, process, analyze, display, and disseminate planning and operational data and perform other related tasks.

(Joint Pub l-02)

command. 1. The authority that a commander in the Armed Forces lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel. 2. An order given by a commander; that is, the will of the commander expressed for the purpose of bringing about a particular action. 3. A unit or units, an organization, or an area under the command of one individual. See also air command; area command; base command; combatant command; combatant command (command authority).

(Joint Pub l-02)

commonality. A quality which applies to materiel or systems: a. possessing like and interchangeable characteristics enabling each to be utilized, or operated and maintained, by personnel trained on the others without additional specialized training. b. having interchangeable repair parts and/or components. c. applying to consumable items interchangeably equivalent without adjustment.

(Joint Pub l-02)

communications security. The protection resulting from all measures designed to deny unauthorized persons information of value which might be derived from the possession and study of telecommunications, or to mislead unauthorized persons in their interpretation of the results of such possession and study. Also called COMSEC. Communications security includes: a. cryptosecurity; b. transmission security; c. emission security; and d. physical security of communications security materials and information. a. cryptosecurity-The component of communications security that results from the provision of technically sound cryptosystems and their proper use. b. transmission security-The component of communications security that results from all measures designed to protect transmissions from interception and exploitation by means other than cryptanalysis. c. emission security-The component of communications security that results from all measures taken to deny unauthorized persons information of value that might be derived from intercept and analysis of compromising emanations from crypto-equipment and telecommunications systems. d. physical security-The component of communications security that results from all physical measures necessary to safeguard classified equipment, material, and documents from access thereto or observation thereof by unauthorized persons.

(Joint Pub l-02)

communications. A method or means of conveying information of any kind from one person or place to another.

(Joint Pub l-02)

compatibility. Capability of two or more items or components of equipment or material to exist or function in the same system or environment without mutual interference.

(Joint Pub l-02)

control. Authority which may be less than full command exercised by a commander over part of the activities of subordinate or other organizations.

(Joint Pub l-02)

information. The meaning that a human assigns to data by means of the known conventions used in their representation.

(Joint Pub l-02)

interdiction. An action to divert, disrupt, delay, or destroy the enemy's surface military potential before it can be used effectively against friendly forces.

(Joint Pub l-02)

interoperability. 1. The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. 2. The condition achieved among communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. The degree of interoperability should be defined when referring to specific cases.

(Joint Pub l-02)

joint air operations center. A jointly staffed facility established for planning, directing, and executing joint air operations in support of the joint force commander's operation or campaign objectives. Also called JAOC.

(Approved for inclusion in the next edition of Joint Pub l-02)

joint air operations plan. A plan for a connected series of joint air operations to achieve the joint force commander's objectives within a given time and theater of operations.

(Approved for inclusion in the next edition of Joint Pub l-02)

joint air operations. Air operations performed with air capabilities/forces made available by components in support of the joint force commander's operation or campaign objectives, or in support of other components of the joint force.

(Approved for inclusion in the next edition of Joint Pub l-02)

joint force air component commander. The joint force air component commander derives authority from the joint force commander who has the authority to exercise operational control, assign missions, direct coordination among subordinate commanders, redirect and organize forces to ensure unity of effort in the accomplishment of the overall mission. The joint force commander will normally designate a joint force air component commander. The joint force air component commander's responsibilities will be assigned by the joint force commander (normally these would include, but not be limited to, planning, coordination, allocation, and tasking based on the joint force commander's apportionment decision). Using the joint force commander's guidance and authority, and in coordination with other Service component commanders and other assigned or supporting commanders, the joint force air component commander will recommend to the joint force commander apportionment of air sorties to various missions or geographic areas. Also called JFACC.

(Joint Pub t-02)

joint integrated prioritized target list. A prioritized list of targets and associated data approved by a joint force commander and maintained by a joint task force. Targets and priorities are derived from the recommendations of components in conjunction with their proposed operations supporting the joint force commander's objectives and guidance. Also called JIPTL.

(Approved for inclusion in the next edition of Joint Pub l-02)

joint special operations air component commander. The commander within the joint force special operations command responsible for planning and executing joint special air operations and for coordinating and deconflicting such operations with conventional nonspecial operations air activities. The joint special operations air component commander normally will be the commander with the preponderance of assets and/or greatest ability to plan, coordinate, allocate, task, control, and support the assigned joint special operations aviation assets. The joint special operations air component commander may be directly subordinate to the joint force special operations component commander or to any nonspecial operations component or joint force commander as directed. Also called JSOACC.

(Joint Pub l-02)

joint target list. A consolidated list of selected targets considered to have military significance in the joint operations area.

(Joint Pub I-02)

joint targeting coordination board. A group formed by the joint force commander to accomplish broad targeting oversight functions that may include but are not limited to coordinating targeting information, providing targeting guidance and priorities, and preparing and/or refining joint target lists. The board is normally comprised of representatives from the joint force staff, all components, and if required, component subordinate units. Also called JTCB.

(Joint Pub i-02)

list of targets. A tabulation of confirmed or suspect targets maintained by any echelon for informational and tire support planning purposes.

(Joint Pub I-02)

master air attack plan. A plan that contains key information that forms the foundation of the joint air tasking order. Also called the air employment plan or joint air tasking order shell. Information which may be included: joint force commander guidance, joint force air component commander guidance, support plans, component requests, target update requests, availability of capabilities/forces, target information from target lists, aircraft allocation, etc. Also called MAAP.

(Approved for inclusion in the next edition of Joint Pub I-02)

mission. 1. The task, together with the purpose, that clearly indicates the action to be taken and the reason therefore. 2. In common usage, especially when applied to lower military units, a duty assigned to an individual or unit; a task. 3. The dispatching of one or more aircraft to accomplish one particular task.

(Joint Pub l-02)

national communications system. The telecommunications system that results from the technical and operational integration of the separate telecommunications systems of the several executive branch departments and agencies having a significant telecommunications capability. Also called NCS.

(Joint Pub l-02)

national military command system. The priority component of the Worldwide Military Command and Control System designed to support the National Command Authorities and Joint Chiefs of Staff in the exercise of their responsibilities. Also called NMCS.

(Joint Pub l-02)

request confirmation. A message that informs requesting command and tasking authority of action being taken on air mission requested by ah support request. Also known as REQCONP.

(This term and its definition are applicable only in the context of this publicaation and cannot be referenced outside this publication.)

service component command. A command consisting of the Service component commander and all those Service forces, such as individuals, units, detachments, organizations, and installations under the command, including the support forces that have been assigned to a combatant command or further assigned to a subordinate unified command or joint task force.

(Joint Pub I-02)

sortie allotment message. The means by which the joint force commander allots excess sorties to meet requirements of his subordinate commanders which are expressed in their air employment/allocation plan. Also called SORTIEALOT.

(Approved for inclusion in the next edition of Joint Pub l-02)

sortie. In air operations, an operational flight by one aircraft.

(Joint Pub l-02)

standardization. The process by which the Department of Defense achieves the closest practicable cooperation among the Services and Defense agencies for the most efficient use of research, development, and production resources, and agrees to adopt on the broadest possible basis the use of: a. common or compatible operational, administrative, and logistic procedures; b. common or compatible technical procedures and criteria; c. common, compatible, or interchangeable supplies, components, weapons, or equipment; and, d. common or compatible tactical doctrine with corresponding organizational compatibility.

(Joint Pub l-02)

strategic mission. A mission directed against one or more of a selected series of enemy targets with the purpose of progressive destruction and disintegration of the enemy's warmaking capacity and his will to make war. Targets include key manufacturing systems, sources of raw material, critical material, stockpiles, power systems, transportation systems, communication facilities, and other such target systems. As opposed to tactical operations, strategic operations are designed to have a long-range, rather than immediate, effect on the enemy and its military forces,

(Joint Pub l-02)

tactical command, control, communications, and computer system(s). The facilities, equipment, communications, procedures, and personnel essential to theater level and below commanders for planning, directing, and controlling operations of assigned and attached forces pursuant to the mission assigned and which provide(s) for the conveyance and/or exchange of data and information from one person or force to another.

(Approved for inclusion in Joint Pub l-02)

tactical control. Command authority over assigned or attached forces or commands, or military capability or forces made available for tasking, that is limited to the detailed and, usually, local direction and control of movements or maneuvers necessary to accomplish missions or tasks assigned. Tactical control may be delegated to and exercised at any level below the level of combatant command. Also called TACON.

(Joint Pub l-02)

target analysis. An examination of potential targets to determine military importance, priority of attack, and weapons required to obtain a desired level of damage or casualties.

(Joint Pub l-02)

target list. The listing of targets maintained and promulgated by the senior echelon of command; it contains those targets that are to be engaged by supporting arms, as distinguished from a "list of targets" that may be maintained by any echelon as confirmed, suspected, or possible targets for informational and planning purposes.

(Joint Pub l-02)

target system. 1. All the targets situated in a particular geographic area and functionally related. 2. A group of targets which are so related that their destruction will produce some particular effect desired by the attacker.

(Joint Pub I-02)

targeting. 1. The process of selecting targets and matching the appropriate response to them, taking account of operational requirements and capabilities. 2. The analysis of enemy situations relative to the commander's mission, objectives, and capabilities at the commander's disposal, to identify and nominate specific vulnerabilities that, if exploited, will accomplish the commander's purpose through delaying, disrupting, disabling, or destroying enemy forces or resources critical to the enemy.

(Joint Pub l-02)

telecommunication. Any transmission, emission, or reception of signs, signals, writings, images, sounds, or information of any nature by wire, radio, visual, or other electromagnetic systems.

(Joint Pub l-02)

Appendix F

Study Charter

The objective of the SAB study on *Vision of Aerospace Command and Control For the 21st Century* was to produce a "Capstone" document that captures the Air Force's plan for modernizing its C4ISR systems, including:

- command and control philosophy and needs-what are the unique characteristics the Air Force needs to command and control forces in support of joint warfighting,
- current C4ISR configuration—CAOC, KCOIC, CENTAF Configurations (IDEFF Models),
- C4ISR "Vision" — a description of the future command and control architecture, the relevant "standards" that must be enforced, and an explanation of how to command and control forces in the future,
- C4ISR migration plans-"Quad Charts" and other documentation reflecting investment strategy to attain the future Vision,
- C4ISR modernization process-a description of the process the Air Force needs to institutionalize to insure a rapid exploitation of technology advances.

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Appendix G

Study Participants

Name	Affiliation
Capt C. Athearn	SAF/AQP
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Mr. J. Buchheister	SAF/AQI
Col R. S. Bunn	AMUDOU
Dr. D. Burton	SAB (Grumman Melbourne Systems)
Mr. w carter	Lockheed Martin
Maj Gen J. Corder, USAF (Ret)	SAB (Private Consultant)
Mrs. N. Crawford	RAND Corporation
Maj T. Cristler	SAF/AQII
Maj W. Eliason	AF/XOOC
Maj M. C. Englund	AF/SC
Maj M. Hatcher	AF/XOFI
Lt Col M. Hodgkin	AF/SCXP
Mr. R. Jacob	46 TW/CA
Col M. Livingston	AIA/DOX
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Col B. Queen	SAF/AQPC
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Mr. M. Schoenfeld	Boeing Defense and Space Group
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Dr. G. Weissman	ANSER Corporation
Lt Col C. Westenboff	AF/XOA

* Study Chairman

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Appendix H

Distribution List

Headquarters Air Force	
SAF/OS	Secretary of the Air Force
AF/CC	Chief of Staff
AF/CV	Vice Chief of Staff
AF/CVA	Assistant Vice Chief of Staff
AF/ST	Chief Scientist
AF/TE	Test and Evaluation
AF/LRP	Long Range Planning
AF/HO	Historian
Assistant Secretary for Acquisition	
SAF/AQ	ASAF, Acquisition
AQX	Management Policy and Program Integration
AQL	Special Programs
AQI	Information Dominance
AQP	Global Power
AQQ	Global Reach
AQS	Space and Nuclear Deterrence
AQR	Science, Technology and Engineering
Assistant Chief of Staff, Intelligence	
AF/IN	ACS, Intelligence
INX	Plans and Policy
INR	Resource Management
Deputy Chief of Staff, Plans and Operations	
AF/XO	DCS, Plans and Operations
XOO	Operations
XOR	Operational Requirements
XOF	Forces
XOX	Plans
XOM	Modeling, Simulation and Analysis
Deputy Chief of Staff, Logistics	
AF/LG	DCS, Logistics

Deputy Chief of Staff, Command, Control, Communications, Computers	
AF/SC	DCS, C4
SCM	C4 Mission Systems
SCT	C4 Architectures, Technology and Interoperability
SCX	Plans, Policy and Resources
Directorate of Programs and Evaluation	
AF/PE	
AFPEO/AT	Airlift and Trainers
AFPEO/SP	Space Programs
AFPEO/FB	Fighter and Bomber Programs
AFPEO/C3	c3 Programs
AFPEO/BA	Battle Management
AFPEO/WP	Weapons
AFPEO/JL	Joint Logistics Systems
Office of the Secretary of Defense	
OUSD (A)	Under Secretary for Acquisition
USD (A)/DSB	Defense Science Board
DDR&E	Director, Defense Research & Engineering
ASD/C3I	Assistant Secretary of Defense for C3I
OUSD (AT)	Deputy Under Secretary for Advanced Technology
BMDO	
DARPA	
Other Air Force	
AFMC ST WL, AL, PL, RL, AFOSR ESC. ASC, HSC, SMC	Air Force Materiel Command Science and Technology Labs and AFOSR Product Centers
ACC	Air Combat Command
AMC	Air Mobility Command
AFSPC	Air Force Spacc Command
PACAF	Pacific Air Forces
USAFE	US Air Forces Europe
AFOTEC	Test and Evaluation Center
AFSOC	Air Force Special Operations Command
AIA	Air Intelligence Agency
NAIC	National Air Intelligence Center
USAFA	Air Force Academy

AU	Air University
AFIWC	Information Warfare Center
AFIT	Air Force Institute of Technology
NGB/CF	National Guard Bureau
AFSAA	Air Force Studies and Analysis Agency
Army	
ASA (RD&A)	Assistant Secretary of the Army for Research, Development and Acquisition
ASB	Army Science Board
Navy	
ASN (RD&A)	Assistant Secretary of the Navy for Research, Development and Acquisition
NRAC	Naval Research Advisory Committee
NAWC	Naval Air Warfare Center
NRL	Naval Research Laboratory
Joint Staff	
JCS	Office of the Vice Chairman
J2	Intelligence
J3	Operations
J5	Strategic Plans and Policies
J6	C3 Systems
Other	
Study Participants	
Aerospace Corporation	
ANSER	
MITRE	
MIT Lincoln Lab	
RAND	
SEI	
IDA	
Air Force Science and Technology Board	
Naval Studies Board	

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